8

Facilitating Recovery of Coho Salmon and Other Anadromous Fishes of the Klamath River

Restoration of anadromous fishes to higher abundances in the Klamath basin will require multiple interactive initiatives and will take many years to reach full effectiveness. This chapter emphasizes actions needed for recovery of coho salmon; the same actions likely will benefit other species as well. Remedial actions to be evaluated here include restoration of tributary habitat, restoration of mainstem flows and habitats in the Klamath River, removal of dams, changes in land use and water management, changes in operation of hatcheries, and creation of an institutional framework for fisheries management. Research and monitoring programs are the means by which remedial actions should be evaluated and adjusted.

RESTORATION OF TRIBUTARIES

Coho salmon, spring-run Chinook salmon, and summer steelhead depend heavily on tributaries to complete their life cycles and sustain their populations (Chapter 7). Thus, restoring large, self-sustaining runs of anadromous fishes in the basin requires restoration of the tributaries to conditions that favor spawning and rearing of anadromous fishes. For most of the tributaries, restoring low summer temperatures probably is the most important action (Table 8-1). Removing barriers, improving physical habitat, and increasing minimum flows also are important and are strongly linked to the objective of lowering summer temperatures.

Because the four main tributaries differ from each other, a uniform approach to management and restoration in their watersheds is unlikely to succeed. The following discussion outlines key issues that confront restoration of salmonids in each watershed. This review is not exhaustive; it focuses on the most important factors that appear to limit coho salmon and other anadromous species in the basin.

Table 8-1. Factors Likely to Limit Production of Coho and Other Salmonids in the Shasta, Scott, Salmon, and Trinity Rivers and Their Tributaries

Limiting Factors	Shasta, Main	Shasta, Tributaries	Scott, Main	Scott, Tributaries	Salmon, Main	Salmon, Tributaries	Trinity, Main	Trinity, Tributaries
Migration Barriers								
Dams, weirs, diversion structures	x	x	o	x	-	-	x	o
Low-flow blockage	x	x	x	x	o	o	x	o
Thermal barriers	x	x	x	-	o	-	-	-
Hydrologic Changes								
Low summer and fall flows	x	x	x	x	-	-	-	o
Reduced peak winter flows	o	-	-	-	-	-	x	-
Reduced spring flows due to diversions	o	o	o	o	-	-	x	o
Reduced base-flow support from ground water	x	x	x	x	-	-	-	-
Water Quality								
High temperature	x	x	x	-	o	o	o	o
Low dissolved oxygen (DO)	x	x	o	-	-	-	-	-
pH, alkalinity, dissolved solids	-	-	-	-	-	-	-	-
Suspended solids	-	-	o	o	o	o	o	o
Geomorphology								
Loss of spawning gravel	x	o	x	x	o	-	x	x
Fine sediment deposition	x	x	x	x	o	-	x	x
Channel aggradation and instability	x	o	x	x	-	-	x	x
Reduced in-stream cover	x	o	x	o	-	-	x	x
Loss of riparian cover	x	x	x	o	-	-	o	x
Land Use Constraints								
Timber management practices	-	o	x	x	o	o	x	x
Grazing and pasture in riparian areas	x	x	x	o	-	-	o	o
Grazing in upslope areas	-	o	-	o	-	-	o	o
Management of fuels	-	o	-	x	x	x	o	o
Land conversion for agriculture	x	x	x	o	-	-	-	o
Unscreened diversions	x	x	x	x	-	-	-	o
Tailwater return flows	x	-	x	-	-	-	-	-
Water development	x	x	x	o	-	-	x	o
Urbanization	o	o	o	-	-	-	-	-

Abbreviations: o, common and of moderate concern or significance; x, widespread or important; -, probably not a limiting factor.

Shasta River

The Shasta River once was one of the most productive salmon streams in California (Snyder 1931, Wales 1951). It supported large runs of Chinook salmon, coho salmon, and steelhead. Over 80,000 Chinook salmon spawned in the river in the 1930s, by which time the population probably was already in serious decline as a result of habitat changes caused by placer mining and agriculture starting in the 1850s. Snyder (1931, p.73) referred to it as early as 1931 as a "stream once famous for its trout and salmon." The historical runs of coho salmon and steelhead are not known but were probably large, given the apparent quality of the habitat. An assessment of the river in the 1960s suggested that runs of coho averaged around 1000 fish per year runs of s and teelhead averaged around 6000 fish per year (CDFG 1965).The productivity of the Shasta River is related to its unusual hydrology and geologic setting (Chapter 4). Unlike the Scott and Salmon rivers, the Shasta River is dominated by groundwater discharge, principally through numerous coldwater springs. The headwaters of the Shasta watershed lie primarily on the northern and western flanks of Mt. Shasta. Rainfall and snowmelt recharge an extensive groundwater system that feeds the Shasta River. Historically, the river flowed at a minimum of about 200 cfs all year. The water was cool in summer and, in comparison with its companion watersheds, warm in winter. The exceptional thermal stability of the Shasta made it one of the most important tributaries for support of salmonids in the Klamath watershed.

Today, agricultural development of the Shasta valley (principally alfalfa and irrigated pasture) and the construction of Dwinnell Dam (which impounds the Shastina Reservoir) have fundamentally changed the hydrology and productivity of the Shasta River. The largest diversion of water is to the Shastina Reservoir, constructed in 1926, which loses a substantial part of its storage each year through seepage and blocks access to about 22% of the historical salmonid habitat. Surface diversions and loss of spring flow to the channel because of groundwater withdrawals have reduced summer flows to about 10% of their historical rates. The low volume of flow, high contribution of warm agricultural return flows, and loss of riparian shading lead to summer water temperatures that consistently exceed acute and chronic thresholds for salmonids. Because of high water temperatures, the Shasta River in summer supports mainly nonsalmonid fishes, such as the brown bullhead and speckled dace. Juvenile fall-run Chinook salmon have emigrated by summer, and juvenile steelhead and coho persist mainly in the upper reaches of a few tributaries.

Given its former productivity, the Shasta River has exceptional potential as a restoration site for coho salmon as well as steelhead and Chinook salmon. Although multiple factors limit the abundance of salmonids in the Shasta (Chapter 4), the key to their recovery is to restore enough coldwater flow to keep the daily mean temperatures of the river below 20°C throughout summer. This would allow juvenile salmonids, including coho, to reoccupy the main stem of the Shasta, where they could take advantage of the river's naturally high productivity. Flows must also be restored in several key tributaries (such as Parks Creek and Big Springs) to improve their connectivity with the main river and to provide access to spawning sites.

The restoration of coldwater flows to the Shasta River presents many difficulties. The science behind restoration of the system, however, is relatively simple. Given the magnitude of the groundwater recharge area that is connected to the Shasta River, there appears to be ample potential to restore cool flows (Chapter 4). Additions of cool water to the relatively small volume of current summer flows are likely to have a substantial beneficial effect on temperature and habitat. Modest changes in the timing and magnitude of surface diversions and groundwater pumping, particularly in the upper reaches of the Shasta River and the tributaries between Dwinnell Dam and Big Springs, would have a large beneficial effect on the volume and temperature of water in the river during summer. Because the thermal mass of present flows is small, the benefits of cooling the water may be limited to the upper reaches of the river. If new water-management programs are linked to programs that seek restoration of riparian zones and channels, however, it is very likely that a substantial portion of the Shasta River can be restored to highly productive rearing habitat for coho and other salmonids. It is also appropriate to consider removal of the aging Dwinnell Dam. It loses more water to seepage than it provides for irrigation (Chapter 4), and its removal would restore flows, increase gravel recruitment, and allow access of salmonids to 22% of their historical habitat.

Numerous stakeholder groups and several federal and state agencies are now addressing habitat issues for salmonids in the Shasta watershed. Although not as well funded as the Scott River programs, the Shasta River restoration efforts are making progress, particularly in riparian fencing and management of tailwater return flow. To restore habitat effectively, these groups must develop methods for augmentation of the Shasta River with cool water during summer. Habitat restoration efforts that fail to deal with this issue are unlikely to succeed. A federally organized program promoting technical review of private habitat restoration efforts could make such efforts more successful.

Scott River

The Scott River originates in forested headwaters of the Marble, Scott, and Trinity mountains, meanders through the broad, agriculturally rich Scott valley, and then passes through the steep Scott River Canyon before joining the Klamath River (Chapter 4). The surrounding mountains are largely national forest, including the Marble Mountains Wilderness Area. The Scott River valley is private agricultural land, and the canyon reach below it is a state Wild and Scenic River (CDFG 1979b). The Scott River exhibits strongly seasonal flows derived from numerous tributaries that drain the western and southern edges of the watershed. The tributaries were and are critical for spawning and rearing of coho and steelhead, and the meandering river on the valley floor was important for spawning of fall-run Chinook and Pacific lamprey. It is likely that in all but the most severe drought years the main stem originally provided important and productive habitat for juvenile salmonids, including coho, throughout the summer, especially in the sloughs and pools of the numerous beaver dams that once were characteristic of the streams on the valley floor (CDFG 1979b).

The Scott River is still an important spawning area for salmonids, as indicated by the annual outmigrant trapping by the California Department of Fish and Game (e.g., Chesney 2002). Numbers of fish are severely diminished, however, and habitat is poor for one or more stages of the life history of all anadromous salmonids (CDFG 1979b). The decline in habitat for salmonids in the watershed has multiple, linked causes (summary in Chapter 4). In the forested western and southern margins of the watershed, intense logging and associated road building on highly erosive soils has produced high sediment yields. Tributaries draining that portion of the watershed have been degraded by deposition of fine sediments. In the lower portion of the tributaries, extensive diversions for irrigation remove water from streams during summer. In the valley, grazing and farming have reduced riparian cover on tributaries and on the main stem. In addition, historical placer mining in the main stem and some tributaries has severely degraded spawning habitat, and has formed migration barriers during low-flow years. The most important effect on salmonid habitat is associated with high water demand for alfalfa and irrigated pasture. Surface diversions and groundwater pumping lead to extensive low-flow and no-flow conditions during summer on the main stem and the lower tributaries. Increased reliance on irrigation wells since the 1970s and changes in cropping patterns appear to be the cause of declining flows between late summer and early fall. Low flows reduce or degrade rearing habitat and limit migration during fall. Low-flow conditions on the Scott also are accompanied by poor water quality (Chapter 4). The low volume of water in the river, coupled with the accrual of tailwater return flows, leads to high summer temperatures. Typical maximum weekly average temperatures are well above acute or chronic thresholds for salmon from summer into early fall.

Despite widespread decline in suitability of habitat, the Scott River retains high potential for becoming once again a major producer of anadromous fishes, especially coho salmon. The lower reaches of the tributaries on the west side of the basin, and the south and east forks, are still used extensively by coho and steelhead despite considerable degradation of the habitat. In addition to continuing efforts to reduce sedimentation and restore riparian vegetation cover in the streams, the key to restoring coho and other salmonids is to improve access of fish to the upper basin tributaries and to enhance coldwater flows. Improving access will require additional screening of diversions and removal of blockages but also will require more aggressive management of adjudicated surface diversions and groundwater to maintain sufficient flows for fish passage. Restoration of habitat for salmonids on the main stem of the Scott River also remains a considerable challenge. Low flows and associated high temperatures have the greatest effect on fall-run Chinook and lamprey but may also affect coho, particularly during dry falls. High water temperatures and loss of riparian vegetation probably have eliminated holding and rearing habitat for coho in the main stem. Restoring summer and fall conditions suitable for coho in the main stem will require careful and creative management of existing surface-water and groundwater resources in the Scott River valley. Water leasing and conjunctive use of groundwater and surface water may be the only means of reducing diversions and groundwater pumping during critical low-flow periods.

Multiple stakeholder groups and the local Resource Conservation District in the Scott valley have conducted a number of well-funded efforts to restore habitat in the Scott watershed. Cooperation between these groups and the state and federal agencies that support them appears to be the most effective way of restoring habitat in the basin. To date, however, the groups have not attempted to resolve the most important but intractable issue: increasing the amounts of cold water entering the tributaries and the main stem.

Salmon River

The Salmon River has a steep gradient, is largely forested, and lacks broad alluvial valleys. About 98% of the watershed is in federal ownership, and more than 48% is designated as wilderness. The main stem, forks, and Wooley Creek are designated Wild and Scenic Rivers (CDFG 1979a). Wooley Creek is in nearly pristine condition, which is unique in the Klamath watershed. Most strikingly, the Salmon River is free of dams and is not subject to depletion of flow by diversions.

The Salmon River watershed contains about 140 mi of channel suitable for spawning and rearing of fall-run Chinook salmon and 100 mi of steelhead and coho habitat (CDFG 1979a). Other fishes in the community include spring-run Chinook salmon and summer steelhead, which, like coho salmon, require deep pools and cold water throughout the summer. The principal habitat for spring-run Chinook salmon and summer steelhead in the Salmon River drainage today is Wooley Creek, although small numbers are also found in the forks of the Salmon River as well (Moyle et al. 1995, Moyle 2002) .

Despite natural flow conditions and absence of agriculture, salmonid populations in general are low in the Salmon River, and coho salmon in particular are scarce (Olson and Dix 1993, Brown et al. 1994, Elder et al. 2002). Records are poor, but salmonids most likely were considerably more abundant in the past (CDFG 1979a). Olson and Dix (1993) estimated that only about 25% of the available spawning habitat was used by Chinook salmon and steelhead. The causes of decline and the status of current populations are not clear.

A variety of natural and anthropogenic factors may suppress salmonid populations in the Salmon River. Unlike the Shasta and the Scott rivers—which have alluvial valleys that formed favorable habitat for holding, spawning and rearing of salmon—the Salmon River has a bedrock channel of high gradient that limits the total amount of suitable habitat as defined by depth and velocity. The high rates of uplift in the watershed, coupled with unstable rock types, produce naturally high erosion rates that are associated principally with mass movements (CDFG 1979a). High erosion rates, which are accompanied by high sediment yields, have been accelerated by human activity in the last century (Elder et al. 2002).

In addition to naturally high sediment yields, the Salmon River watershed exhibits strong seasonal variations in flow, including large winter floods and low base flow during the last half of the summer. Low-flow conditions in the summer, particularly during drought, and the scarcity of cold springs may have naturally produced sufficiently high summer temperatures (maximums, 20-26°C) in some tributaries and in the main stem to limit production of salmon within the basin. Thus, the Salmon River watershed, although nearly pristine, may have geologic and hydrologic characteristics that are suboptimal for salmon. Under these conditions, human activities that increase sedimentation or raise stream temperature in the basin could have an especially large effect on salmon and steelhead.

The first major anthropogenic disturbance to the Salmon River was placer mining and other forms of gold mining, which peaked in the basin between 1850 and 1900 but continue today on a small scale (CDFG 1979a, Chapter 4). Placer mining disturbs the channel and disrupts sediment transport processes that sustain spawning gravels and maintain pools. A more important disturbance in recent years has been a combination of logging and fires. Logging and its associated road-building have greatly increased erosion on the steep and fragile slopes of the watershed and have reduced shading of small tributaries, thus increasing water temperatures. Stream crossings also significantly impair tributary streams in this basin by forming barriers to migration and local sources of erosion. Large fires may have exacerbated the effects of logging in the basin. Almost 30% of the basin has burned in the last 25 yr, and most fires have occurred in the logged portions of the basin (Salmon River Restoration Council 2002). These catastrophic fires, coupled with extensive logging that follows fires ("salvage logging"), have greatly increased the number of logging roads and increased the frequency of landslides (CDFG 1979a, Elder et al. 2002). Elder et al. (2002) estimated that from 1944 to 1988 about 216 mi of stream in the basin were scoured by debris flows caused by landslides. In addition, poaching of the vulnerable adult summer steelhead and spring-run Chinook may be important in reducing their populations (West et al. 1990, Moyle et al. 1995).

Factors outside the basin—including ocean or estuary conditions, harvest, and conditions on the Klamath main stem—may have reduced adult populations of salmonids in the Salmon River. Overall, however, it is likely that land-use activities in the Salmon River watershed have had the largest adverse effects on production of salmon and steelhead in the Salmon River basin.

Because the Salmon River watershed is owned principally by the federal government, there has been comparatively little controversy surrounding management and restoration efforts within the basin. A small but growing stakeholder group is cooperating with state and federal agencies and tribal interests in the Salmon River basin. High priority has been placed on monitoring of salmon and steelhead runs, improvements in riparian habitat, management of fuels, and assessment and rehabilitation of logging roads (Elder et al. 2002). Given proper funding and agency participation, these efforts may be sufficient to improve conditions for coho and other salmon and steelhead in the watershed.

Trinity River

Because the Trinity is the largest tributary of the Klamath River and enters only 43 mi upstream of the estuary, management and investigative efforts by the agencies have regarded it as if it were a separate river system. The creation in 1963 of the Lewiston and Trinity dams combined with the transbasin diversion of a significant proportion of the annual flow further enforces this impression of separation. Even so, the Trinity River flows influence water temperature and quality in the lower Klamath River and its estuary.

The Klamath River below Iron Gate Dam and the Trinity River have the same fish fauna, including the runs of salmon, which belong to the same ESUs (Moyle 2002). Chinook salmon, for example, have two ESUs: the Upper Klamath and Trinity ESU and the Southern Oregon and California ESU, the latter of which includes salmon in the lower Klamath and Trinity rivers. Both genetic evidence and marked hatchery fish demonstrate that salmon and steelhead from the two systems continuously mix. In addition, both systems have large hatcheries that produce coho salmon, Chinook salmon, and steelhead. Immigrating spawning adults and emigrating smolts from the Trinity River rely on lower Klamath River water temperature and quality to support their success in terms of egg quality, osmoregulatory ability, and survival. Thus, efforts to conserve coho salmon and other declining fishes must take both systems into account.

Data on the numbers of salmon and steelhead returning each year to the Trinity River and its tributaries are fragmentary and incomplete. There is general agreement, however, that populations of the most sensitive salmonids (coho, spring-run Chinook, and summer steelhead) have declined considerably (perhaps 90% or more) to a few hundred individuals of wild origin

(Moyle et al. 1995, Moyle 2002, CDFG 2002). Populations of winter steelhead and fall-run Chinook also are much lower than they historically were, but there are few estimates before 1977. Between 1977 and 1999, fall-run Chinook salmon escapement was estimated to range from about 7,000 to 125,000 fish; fewer than 25,000 spawners were present in 12 of 23 years (CDFG 1999). From 1992 through 1996, only about 1900 adult steelhead were recorded in the river above the confluence with the North Fork River each year; this is only 5% of goals set in 1983, which were based on estimates of historical abundances (USFWS 1999). The Trinity River Hatchery releases large numbers of juvenile coho, steelhead, and fall-run Chinook each year, but its role in maintaining the present runs is not well understood. Although the hatchery has been in operation since 1964, it has failed to prevent the continued decline of salmon and steelhead populations. In years when the numbers of returning Chinook salmon are low, percentages of hatchery Chinook in the run can be as much as 40-50%.

Causes of the decline in coho and other anadromous fishes are similar to those elsewhere in the Klamath basin (USFWS 1999). Some of the most important probable causes of decline specific to the Trinity River include construction of dams and associated regulation, enhancement of erosion associated with logging and grazing practices, placer mining, and hatchery operations. Construction of Lewiston and Trinity dams in the main stem in 1963 blocked access to over 109 mi of salmonid spawning habitat (cold water, good gravels), including 59 mi of spawning habitat for Chinook salmon. The dams and associated water diversion also reduced flows downstream, blocked recruitment of gravel to areas downstream of the dam, and reduced rates of channel-forming geomorphic processes. Extensive poorly managed logging and road building on steep slopes with highly unstable soils, followed by large fires, have resulted in a high frequency of landslides and erosion that cause high sediment loads in the river and its tributaries. Massive erosion triggered by the floods of 1964 in particular resulted in large-scale destruction of spawning and rearing habitat. In addition, extensive placer mining for gold in the 19th century, and to some extent into the 20th century, resulted in loss of spawning and rearing habitat that still persists in many places. Finally, the Trinity River Hatchery has a major effect on wild populations of coho salmon, Chinook salmon, and steelhead, given that marked hatchery fish are frequently observed spawning in the wild. It is possible that hatchery production is suppressing populations of wild fish (e.g., Kostow et al. 2003), especially of coho salmon, but this has not been studied in the Trinity basin.

The South Fork Trinity River is one of the largest tributaries within the Klamath basin. Although poorly documented, historical salmon and steelhead runs within the South Fork were very large, and included coho. Poor logging and grazing practices on unstable soils in the South Fork Trinity coupled with highly destructive floods in 1964, destroyed most spawning and rearing habitat within the South Fork. Although habitat conditions appear to be improving, this tributary adds little to the overall salmon and steelhead productivity of the basin.

Recognition that runs of anadromous fish in the Trinity River are declining and in need of recovery has led to many restoration projects throughout the basin. Friends of the Trinity River, for example, estimate that nearly $100 million was spent on restoration projects in the basin from 1983 through 2000 (FOTR 2003). The 1999 EIS/EIR on dam operations indicated that reduced flows below Lewiston Dam, especially in spring, had significantly altered salmonid habitat in the Trinity River. As a result, the Secretary of the Interior in December 2000 issued a Record of Decision (ROD) recognizing that long-term sustainability of the Trinity River's fishery resources requires rehabilitation of the river. The ROD called for specific annual flows designed to vary with water-year type and patterned to mimic natural variability in annual flows. The ROD also specified physical channel rehabilitation, sediment management, and watershed restoration efforts throughout the basin (USFWS 1999, 2000). Additionally, the ROD called for an Adaptive Environmental Assessment and Management (AEAM) program, guided by the Trinity Management Council, to use sound scientific principles in guiding the course for recovery in the Trinity River basin. Because of lawsuits by Central Valley water users challenging the EIS/EIR, however, the new flow regime has not yet been fully implemented.

Poor land-use practices and water diversions have reduced the capacity of the Trinity River to support coho salmon and other anadromous fishes. There are no quick fixes for problems that are so severe and pervasive. Some of the measures that could be taken to improve the situation for salmonids both in the Trinity and the lower Klamath River already have been identified in the ROD, and in sediment TMDLs for the main stem and the South Fork (EPA 1998, 2001). The proposed flow schedule for the mainstem Trinity attempts to manage releases in a flexible manner that benefits aspects of the life histories of multiple species while responding to interannual variability in runoff conditions. Coho may benefit less than other species from mainstem flow alterations, however, due to their affinity with smaller tributaries.

Only large-scale restoration projects can reverse the adverse effects of logging, grazing, mining, and fires in the Trinity basin. Effective actions include removal of roads; elimination of logging, grazing, and off-road vehicle use from sensitive areas; planting and protection of trees to reduce erosion and restore riparian zones; and use of any other means to reduce erosion rates. Channel restoration and rehabilitation projects need to focus on restoring key geomorphic attributes of alluvial channels. These actions are called for by the ROD and are to be guided by the Trinity Management Council. Given that 80% of the lands within the Trinity basin are federally managed, large gains could be realized. It is unclear, however, whether these efforts will be restricted only to the areas immediately downstream of Lewiston Dam or, more appropriately, will be applied throughout the entire watershed, including the South Fork. A watershed approach is likely in the long run to be more successful than localized restoration. For coho salmon, physical restoration and protection of cold-water sources in tributaries that were historically important for spawning and rearing are of key importance.

Estimates of numbers of spawners of coho and other salmonids are needed as an index of the effectiveness of restoration efforts. The concept of numerical restoration goals, as set in 1983 and adopted by the 1999 EIR, is valid, but should be reviewed using information from such sources as the Indian fishery and extent of original habitat. The restoration goals must apply to fish spawning in tributaries as well as in the main stem. Goals should include minimum numbers (e.g., following years of poor ocean conditions) as well as numbers for years of average conditions.

The many small restoration projects in the basin should be continued, but should be viewed as experiments in adaptive management that ultimately will demonstrate the most effective treatments for Trinity River problems. Coordination of existing projects with those outlined in the ROD should be expanded.

It is vital that management of the Trinity River, including releases from Lewiston Dam, be viewed in the context of the entire Klamath watershed. The two systems are inextricably linked and are dependent upon each other for long-term success. Efforts presently are underway to use enhanced flow releases from the Trinity to reduce the likelihood of fish kills in the lower Klamath. This represents an important step forward in cooperative management for the sake of the entire basin, rather than a single component.

Small Mainstem Tributaries

About 50 permanent streams, many of which are quite small, flow into the mainstem Klamath between Iron Gate Dam and the mouth of the Klamath. The streams formerly supported substantial runs of steelhead, coho, and other anadromous fishes (Kier Associates 1998). The watersheds of most of the tributaries have been extensively logged, and many roads have been constructed in them. Irrigation diversions in the largest of the tributaries have reduced their summer flows. The status and trends of fish populations in individual tributaries for the most part are not well known, although Blue Creek and other nearby streams are being monitored by the Yurok Tribe (e.g., Gale et al. 1998, Hayden and Gale 1999). Most of these tributaries probably support far fewer adult and juvenile anadromous fish than they once did, because of changes to habitat caused by logging, mining, agriculture, and road construction, and as a result of water diversions. Restoration of habitat, low temperatures, and flows in these small streams would be of major benefit to tributary-spawning species—especially coho salmon, steelhead, and cutthroat trout—and potentially could improve rearing conditions for juvenile salmonids in the Klamath main stem by cooling the pools at the mouths of small tributaries. The emphasis on these restoration efforts should be on those tributaries that have existing or potentially significant sources of cold water.

THE MAINSTEM KLAMATH RIVER

Modeling of Habitat Availability in Relation to Flow

The National Marine Fisheries Service (NMFS) has sponsored habitat availability monitoring in the Klamath main stem in support of the preparation of its biological opinions (NMFS 2001, 2002). The modeling work was reported by Hardy and Addley (2001) in a document commonly referred to as the Hardy Phase II draft report. The NRC Committee was encouraged to consider the final version of this report, but was cautioned against excessive reliance on the draft report on grounds that the final report would contain more thorough model calibration and possibly other changes that might alter the results.

The NRC Committee read and discussed the draft Hardy Phase II report. The committee saw the modeling approach as flawed by heavy reliance on analogies between habitat requirements for Chinook salmon and habitat requirements for coho salmon. Habitat requirements for Chinook salmon are better known, but the behavior and environmental requirements of Chinook salmon differ substantially from those of coho salmon (Chapter 7). To the extent that this approach is carried forward into the final report, the NRC Committee's skepticism about the validity of the analogy would also be carried forward. In addition, the NRC Committee, as explained elsewhere in this chapter, concludes that rearing of coho in the Klamath main stem is much less important than rearing of coho in tributaries, which are the preferred rearing habitat of coho. Thus, the importance that can be attached to regulation of flows in the main stem is probably less, in the viewpoint of the committee, for coho than it would be for Chinook, for example. Because the Hardy Phase II draft report does not deal with tributaries, the analysis in the draft Hardy Phase II diverged from the committee's analysis of the critical requirements for coho.

The committee recognizes that mainstem flow may directly affect the coho population at the time of downstream migration of smolts. While it is unclear whether additional water would favor the success of this migration, it is also clear, even in the absence of modeling, that NMFS can argue, given the absence of data to the contrary, that there is some probability of benefit for the smolts to be derived from minimum flows at the time of smolt migration, as expressed in the NMFS biological opinion of 2002. Adaptive management principles could be applied to this issue.

Management of Flow at Iron Gate Dam

In its biological opinions of 2001 and 2002, NMFS (2001, 2002) called for increases in minimum flows from Upper Klamath Lake via Iron Gate Dam for the benefit of coho salmon. NMFS reasoned that increased flows would increase rearing habitat for juvenile coho salmon, thus increasing their growth and survival in the river. For bioenergetic and ecological reasons (Chapter 7), it is unlikely that increased summer flows would benefit juvenile coho salmon. Additional water would likely be too warm for them (Chapter 4), and their principal habitat affinities during rearing are with the tributaries rather than the main stem. Additional flows would probably benefit Chinook salmon, steelhead, Pacific lamprey, and other more thermally tolerant fishes in the river by providing them with additional rearing habitat.

There is limited flexibility for managing the temperature of releases from Iron Gate Dam. Some cool water flows into Iron Gate Reservoir from springs and tributaries, but it is of little value for cooling the river in summer because of the large volume of the reservoir relative to these accretions. Because the deep waters of Iron Gate Reservoir store cool (hypolimnetic) water throughout the summer, however, it would seem that the construction of a deep withdrawal, coupled with selective aeration of the hypolimnion during the summer, could make available a pool of water for cooling the Klamath main stem below Iron Gate Dam. Unfortunately, the cool summer water has a volume of only about 15,000-18,000 acre ft (M. Deas, personal communication, Watercourse Engineering, Inc., July 16, 2003), which is sufficient to cool the reservoir release for only seven to ten days. Use of the water for cooling would not provide sustained benefits for the fish, and also would remove the source of cool water for the Iron Gate Hatchery, which relies on the deep water of Iron Gate Reservoir for hatchery operations. Furthermore, information from thermal modeling shows that introduction of cool water would provide benefits only for a relatively short distance downstream of the dam, given that summer thermal loading of the mainstem Klamath is high and that accretion of flow from tributaries consists primarily of warm water in summer.

Higher summer flows from Iron Gate Dam appear to increase minimum temperatures by reducing the effect of nocturnal cooling (Chapter 4). Higher flows also may raise the temperatures of the few coldwater refuges available in the mainstem, the pools into which cool tributaries flow. Juvenile salmonids seek these pools during the day but disperse at night as the water cools (M. Deas, Watercourse Engineering, Inc., personal communication, November 25, 2002; unpublished data, USFWS). Even small disturbances to these pools (for example, by anglers) cause the fish to move into unfavorably warm water (M. Deas, Watercourse Engineering, Inc., personal communication, November 25, 2002), potentially harming or killing them. A natural-flow paradigm now commonly referenced in fisheries management is based on the premise that ecosystem functions and processes and the aquatic communities of rivers are affected by deviations from natural flows, including specific seasonal patterns and specific interannual ranges of variability by season (Poff et al. 1997). In the Klamath River, for example, the native fishes evolved with an annual sequence of winter pulse flows (principally from tributaries), high spring flows (from tributaries and the upper basin), and low flows in late summer and fall (principally from the upper basin). Base flows varied with climatic conditions. Some years provided strong winter and spring flooding that connected the channel with the floodplain, redistributed sediment, cleaned gravel, and re-formed the habitat features of the channel; other years had lower flows with much smaller effects. The timing of the flows and the ambient warming of the mainstem Klamath occurred in synchrony with tributary conditions; salmon smolts emigrating from a tributary did not leave a cool, springflow condition to enter a main stem experiencing a warm, summer base-flow condition. Thus, managing stream flows in ways that reflect timing and duration of the unregulated hydrograph is a holistic approach that recognizes climatological reality but can still be consistent with extensive human use of water resources. Such an approach would not demand high base flows in years of drought but could capitalize on years of high flow to maintain and restore habitat. It is also worth noting that historically the upper Klamath basin supplied only a portion of the flows of the lower Klamath River. Thus, increasing flows from the Scott and Shasta rivers would not only have thermal benefits to the main stem but mimic natural sources of flow more closely. Temperature in the lower basin will likely be increasingly important as global climate change occurs (Parson et al. 2001).

THE LOWERMOST KLAMATH AND OCEAN CONDITIONS

The lowermost Klamath is important to coho as an entry and exit point for the main stem. In addition, any substantial change in the hydrograph at the mouth of the Klamath could be expected to influence conditions in the estuary. While it may be attractive to use Trinity flows to influence conditions in the lower Klamath River, it must not occur at the expense of Trinity River restoration goals. Within the ROD for the Trinity River EIS/EIR, watershed restoration and monitoring that benefits fishery resources below the confluence of the Trinity and the Klamath rivers may be considered for action by the Trinity Management Council.

As explained in Chapter 4, total annual flow in the lower Klamath and its estuary has been altered only to a small degree by water development in the upper basin, even though water development has had drastic effects on hydrographs in a number of headwater areas. Thus, changes in total flow are not sufficiently large to suggest significant biological effects on the estuary strictly related to amount of flow. Furthermore, fall flows, even in years of average or above average moisture, tend to be higher than they were historically at the mouth of the Klamath (USFWS/HVT 1999, Hardy and Addley 2001), which would indicate that fall migrations probably have not been impaired by flow depletion per se. Warming of the water and poor water quality have greater potential significance, particularly near the mouth of the Klamath (see the section in Chapter 7 on fish mortality in 2002).

Estuary and ocean conditions undoubtedly induce variation from year to year in the strength of coho migrations. In part these variations are natural, i.e., they may be related to synoptic changes such as those associated with Pacific decadal oscillation or with shorter-term climate variability affecting ocean conditions. In addition, as mentioned in Chapter 4, the estuary and river mouth have undergone chemical changes because of anthropogenic influences upstream. The extent to which these factors are affecting coho populations is unknown at present, however. While favorable ocean conditions may magnify the strengths of certain year classes, any such favorable effects should not be used as a reason for reducing emphasis on improvement of watershed conditions for coho, given that especially good ocean conditions inevitably alternate with poor ocean conditions (NRC 1996).

REMOVAL OF DAMS

Dams often have major adverse effects on native fishes, especially anadromous fishes (Moyle 2002). There is growing national and international recognition that removal of some dams may provide substantial benefits to fish and downstream ecosystems by increasing flows, improving the flow regime, and providing access to upstream habitat (Heinz Center 2002, Hart and Poff 2002). Dams that have been removed so far in the United States primarily have been small and have had low or even negative economic value, although some larger dams have been proposed for removal on grounds that the benefits of removal outweigh the value of the dams and the cost of removal.

All dams (including both large public or corporate dams and small private dams) and diversions in the lower Klamath basin need to be systematically evaluated for their effects on anadromous fishes; those with strong adverse effects should be investigated further for modification or removal. Specifically, Iron Gate Dam should be evaluated for removal in conjunction with recapture of flows in Jenny Creek that are now diverted out of the Klamath basin to the Rogue River. Iron Gate Dam was built in 1962 to re-regulate flows from Copco Dam. Copco Dam was built in 1917 to generate power, mostly at times of peak demand. Water released from the dam on demand caused major daily fluctuations in downstream flows that were harmful to the fish and other ecosystem components (Snyder 1931). Iron Gate Dam was intended to allow more uniformity in the release of water. The reservoir behind the dam flooded about 6 mi of the Klamath River. The flooded mainstem reach and its tributaries apparently were excellent spawning habitat for Chinook, coho, and steelhead (Snyder 1931), probably because of cool water in the tributaries. To mitigate this loss, the Iron Gate Hatchery, which uses water from the reservoir, was built to provide a source of young salmon. The hatchery releases several million juvenile Chinook, coho, and steelhead into the river each year (only about 70,000 per year are coho salmon; see Chapter 7). Iron Gate Reservoir supports a recreational fishery mainly for nonnative yellow perch and stocked rainbow trout.

There has been no systematic evaluation of the benefits and costs associated with the removal of Iron Gate Dam, but removal of the dam would recapture about 6 mi of lost habitat in the main stem of the dam and substantial tributary habitat; the 6-mi reach could also have lower summer water temperatures than most of the main stem. Removal of Iron Gate Dam would require operation of Copco Dam in a more uniform manner, which would result in loss of power revenues from Copco Dam. An alternative water supply also would be needed for the Iron Gate Hatchery. Opportunities for removal of Iron Gate Dam could be considered in the near future under the Federal Energy Regulatory Commission (FERC) relicensing process. The current license for operation expires in 2006; a draft application is due in 2003 (FERC Relicensing Number 2082).

CHANGES IN OPERATION OF HATCHERIES

The reason for building the hatcheries on the Trinity River and at Iron Gate Dam was to ensure that fisheries could be sustained at levels at least as high as they were before the construction of the dams. Despite the operation of the hatcheries, commercial fisheries for Klamath basin fishes have largely been shut down, and sport fisheries have declined; the principal remaining fishery is the tribal subsistence fishery for salmon and sturgeon. Overall, anadromous fish in the basin now reach only a small fraction of their historical abundance. Abundance has declined despite the release of millions of juvenile Chinook, coho, and steelhead into the rivers each year by the hatcheries (Chapter 7). There is growing evidence from numerous river basins that large-scale releases of hatchery fish have an adverse effect on remaining populations of wild fish and do not contribute as much to fisheries as generally supposed (e.g., Hilborn and Winton 1993, Knudsen et al. 2000, Levin et al. 2001, Moyle 2002). Adverse effects can occur even when hatchery coho are stocked in streams ostensibly to help rebuild wild populations (Nickelson et al. 1986).

The effect of the hatchery fish on populations of wild salmonids in the Klamath basin is not well understood, but it probably is negative. For example, the release of millions of juvenile Chinook salmon every June floods the river with fish that are larger than the wild fish. The hatchery fish are likely to displace or stress wild Chinook and coho salmon (Rhodes and Quinn 1998). If food and space are not limiting factors in the river (that is, if the environment is not saturated with fish), hatchery fish would not make much difference in the growth and survival of wild fish. But this is probably not the case, especially as the water warms and fish seek the cool pools at the mouths of tributary streams. Furthermore, not all hatchery fish emigrate as assumed when stocked. Some of the stocked fish may remain in the river, potentially until the following spring, through the process of residualization. Residualization occurs when the smoltification process stops and a juvenile fish reverts to the parr stage (Viola and Schuck 1995). The smoltification process can stop when fish are exposed to temperatures beyond the physiological tolerance for smoltification. In some instances, large fractions of fish remain and compete with wild fish for limited habitat (Viola and Schuck 1995). Residualization has not been studied in the Klamath basin, but its potential for harm to wild fish indicates that it should be studied.

The Klamath and Trinity basins provide an unusual opportunity for large-scale tests of hypotheses relating the effect of hatchery operations to the welfare of wild salmon and steelhead populations. The two basins can be regarded as a paired system in many respects. Because both have production hatcheries for coho, Chinook, and steelhead at the top of the accessible reaches for the species, comparative manipulations of hatchery practices are possible through an adaptive-management framework. For example, the Iron Gate Hatchery could be shut down for 6-8 yr (two Chinook and coho life cycles) while the Trinity River Hatchery remains operational (with the requirement that all fish be marked when released). Such a large-scale experiment would be informative if accompanied by intensive monitoring of juvenile and adult populations. An ecological risk analysis of the costs and benefits of hatchery programs should be conducted (Pearsons and Hopley 1999), especially in relation to coho salmon. If hatchery production results in a net loss of wild coho salmon, hatchery operation should be modified or even terminated.

LAND-MANAGEMENT PRACTICES

Throughout the distribution of coho salmon in the Klamath basin, the effects of land-use practices on the welfare of coho must be closely examined and, where damage to salmon habitat has occurred, restoration must be undertaken. Undesirable practices from the viewpoint of the welfare of coho include augmentation of suspended load through any agricultural practices that enhance erosion, forestry that does not incorporate best management practices, and mining that does not involve strict controls on sediment mobilization or that occurs directly in a stream channel. Coho would almost certainly benefit from regulation of grazing to an extent that involves exclusion of cattle from riparian zones and stream channels. The practice of flash grazing (exposure of riparian zones only for short intervals), while showing the appropriate intent, should be reviewed for actual effectiveness in terms of environmental objectives. Complete exclusion of livestock may be necessary in many instances, at least until woody vegetation is well established, and streambank conditions may never be consistent with the presence of large numbers of cattle, even on a short-term basis. Plans to restore stream channels, while laudable in intent, should be reviewed by federal and state agencies for effectiveness; government should assist landowners in finding the technically most desirable ways of achieving their restoration objectives. Review of channel and riparian conditions and their linkages to land-use practices should be included in a recovery plan for coho salmon (see Chapter 9).

CREATION OF A FRAMEWORK FOR FISH MANAGEMENT

Management of fish in the lower Klamath basin must deal with both harvest and habitat. For most of the history of the basin, regulation of harvest was the primary management tool, and it was complex in that it involved tradeoffs between ocean and river fisheries and among commercial, sport, and tribal fisheries (Pierce 1991). Despite harvest management, salmon and steelhead populations declined. Today, commercial fisheries are banned, and the sport and tribal subsistence fisheries are restricted. Reduced fishing pressure on wild fish populations, especially of coho salmon, is clearly part of the solution to restoration of the populations, but management of harvest does little good if spawning and rearing habitat is inadequate. The Klamath basin requires habitat restoration.

Numerous state and federal laws provide a basis of aquatic-habitat management and drive the policy of government agencies (Gillilan and Brown 1997). Examples of such legislation relevant to the welfare of fish in the lower Klamath basin are as follows:

- The Fish and Wildlife Coordination Act of 1934, which requires federal agencies to consult with state and federal wildlife agencies before any water development or modification project is undertaken;
- The National Environmental Policy Act of 1970, which requires all federal agencies or holders of federal permits to file reports on the potential environmental effects of their actions;
- The Wild and Scenic Rivers Act of 1968, which identifies rivers with special public values and prohibits construction of new dams on designated rivers;
- The Clean Water Act of 1972, which promotes having the natural waterways of the United States be "drinkable, swimmable, and fishable." Under this act, many streams in the Klamath basin have been declared impaired in water quality;
- The Endangered Species Act of 1973 (ESA), which requires the designation of "critical habitat" for endangered and threatened species (see Chapter 9);
- The National Forest Management Act of 1976 (NFMA), which requires national forests to be managed to provide viable, widely distributed populations of all native vertebrates, including fish;
- The Sustainable Fisheries Act of 1996 (SFA), which requires fisheries agencies to identify "essential fish habitat" (EFH) for managed species;
- The Trinity River Stream Rectification Act (1980), which is intended to control erosion and deposition problems that arise from the Grass Valley Creek watershed;
- The Trinity River Basin Fish and Wildlife Management Act (1984), which directed the Secretary of the Interior to develop a management program to restore fish and wildlife populations in the Trinity basin to levels approximating those that existed immediately before the TRD construction;
- The Central Valley Project Improvement Act (1992), section 3406(b), which called for interim flows until the completion of the 12-yr Trinity River Flow Evaluation Study (USFWS/HVT 1999). The provision Congressionally requires the Secretary to implement recommendations resulting from the study.

Collectively, these laws provide a strong mandate to protect and improve fish habitat in the Klamath basin. Occasionally, they have resulted in major shifts in land use or policy to favor fish. For example, the NFMA resulted in the creation of a process that greatly altered management of public forest lands in the Pacific Northwest (Thomas et al. 1993, FEMAT 1993). A number of Klamath River tributaries have been designated "key watersheds" through this process, indicating their importance to anadromous fishes, and steps needed to enhance their ability to support fish have been outlined. For the most part, however, the laws do not require actions; rather, they provide for consultation and documentation of problems and can stimulate action. Their effect usually is to raise public awareness of problems and thus lead to protection or improvement of habitat through legal and social channels or through changes in agency policies.

An example of the potential of federal legislation to influence remedial action without actually requiring it is the EFH provision of the SFA. Like the ESA for listed species, the EFH provision directs fisheries management agencies to look beyond harvest management to habitat management. The provision recognizes that fisheries can be sustained only if habitat is available to support all life-history stages of the harvested species (Fletcher and O'Shea 2000). It does not mandate habitat management, but it does require the identification, by regional fisheries management councils, of the habitat for each species and of the factors adversely affecting the habitat. The results of the identification process are presented to other federal agencies, which are advised to consider them when they undertake activities that might affect the habitat. Implementation of the EFH is a large task, given that hundreds of species are harvested, but virtually no funding has been provided for it (Fletcher and O'Shea 2000). Even so, the EFH provision has been useful in calling public attention to the importance of habitat to the maintenance of fisheries.

The EFH designations made by the Pacific Fisheries Management Council are generic (Pacific Coast Federation of Fisherman's Associations 2002). In this respect they resemble the critical-habitat designation made by NMFS for Southern Oregon/Northern California Coast coho salmon, which includes all existing and historical habitat (Fed. Reg. 64 (86): 24061-24062 [1999]). For the Klamath basin, there is only a general indication that EFH encompasses all anadromous salmonid habitat, present and historical, without regard to species, with a generic description of the habitat requirements of each life-history stage of each species. Despite the lack of enforcement provisions in the EFH requirement of the SFA, it would be worthwhile to designate species-specific EFH in the Klamath basin as a means of assisting decision-making in the many federal, state, and local agencies engaged in land and water management. Ideally, the EFH should be used in setting priorities for conservation and restoration of habitat.

POSSIBLE FUTURE EFFECTS OF CLIMATE CHANGE

Records relevant to the hydrologic cycle in the Klamath watershed are based on about 100 yr of rainfall and runoff records. Probabilistic analyses of the records are used in planning future water-resource management and in designing strategies for restoration of species at risk. Such use of the historical record is based on the assumption that the hydrologic cycle of the past is a general predictor of the hydrologic cycle of the future.

The rapid and substantial rise in atmospheric mixing ratios of carbon dioxide and other greenhouse gas in the industrial era could contribute to a measurable increase in global mean temperatures (IPCC 2001, NRC 2001). Global circulation models (GCMs) indicate that global mean temperatures will rise over the next century and that regional climates will be affected in variable ways (IPCC 2001, Strzepek and Yates 2003).

Regional climate change would probably affect the hydrologic cycle of the Klamath watershed (Snyder et al. 2002, Kim 2001, NAST 2001), but there appears to be no substantial effort on the part of government or private entities to plan for climate change. Planning, if it were to take place, faces two important hurdles. Climate change apparently is assumed to be a distant possibility, to be dealt with after more immediate issues are resolved. It is worthwhile to note, however, that regional climate change could occur over a period considerably shorter than the history of the Klamath Project. A second hurdle is that the current GCMs operate on a spatial scale that cannot resolve regional topographic features, which influence climate in most parts of the West (NAST 2001, Redmond 2003). Multiple efforts are underway to downscale the models so that they project regional climate change more accurately, but current GCMs are not suitable for planning on a watershed scale. Even so, several regional models have sufficient spatial and temporal resolution to allow realistic forecasts of the kinds of changes that are likely in a watershed (e.g., Snyder et al. 2002, Kim 2001, Lettenmaier et al. 1999, Lettenmaier and Hamlet 2003); these models are potentially useful to resource managers even though they might not accurately quantify the magnitude and timing of regional change.

A detailed model of the Klamath basin region at 25 mi resolution has been developed by Snyder et al. (2002). Use of the model demonstrates three important kinds of changes in the hydrology of the Klamath watershed that could occur over the next century: (1) warming, especially at high elevation in spring (April, May); (2) higher total precipitation, especially in spring; and (3) an increase in the ratio of rainfall to snowfall and large decreases in spring snowpack. The changes modeled by Snyder et al. (2002) and others have strong implications for management of water resources and all aquatic species, but especially salmonids (NAST 2001, O'Neal 2002). For salmonids, the most important potential changes include altered timing of snowmelt, lower base flows, and additional warming of water in summer.

Large reductions in snowpack coupled with higher precipitation would increase winter runoff and decrease spring runoff. Land use and water management already have shifted peak runoff (Figure 4-2), and climate change could increase the shift. Decline in spring runoff would have important implications for spring migration of coho salmon and other salmonids. Base flows during summer and fall would most likely decline in response to climate change because of increased evapotranspiration associated with higher temperatures and the concentration of annual runoff in winter. Base flows, especially in tributaries, already are too low and would decline further.

Increases in water temperature, particularly during summer low-flow periods would probably harm coho salmon and anadromous fishes in general (Chapter 7). Climate change could make temperature an even more urgent issue than it is now for the future of salmonids in the Klamath basin.

The effects of climate change in the Klamath basin would probably vary spatially within the basin. For example, the Wood River and the Shasta River both have headwater and groundwater recharge areas that lie at sufficiently high elevation to be more resilient than most stream reaches in the event of temperature increases and associated changes in precipitation. Conservation of cool-water sources in these and similar tributaries is likely to be even more critical in the future than it is now.

Uncertainty in the magnitude and timing of climate change in the Klamath basin and the uncertainty about its timing have discouraged resource managers from developing comprehensive, specific strategies to cope with it. It is important that climate change be addressed in the framework of adaptive management (Chapter 10) through programs that anticipate changes that would accompany warming.

CONCLUSIONS

Conditions in tributary waters are of paramount importance for rearing of coho salmon, as is also the case for spring-run Chinook salmon and summer steelhead, which is in contrast to other stocks of anadromous salmonids, including fall-run Chinook. Tributary waters include both the four main tributaries and numerous small tributaries that enter these main tributaries or enter the Klamath main stem directly. Small tributaries offer exceptional potential for restoration of coho salmon.

Remedial actions intended to promote the welfare of coho salmon are not uniform in type and priority across all tributaries. The Shasta River, which probably has the single largest potential for restoration of coho salmon and anadromous fish in general, shows depression of salmonid stocks caused by extensive diversions and blockage of flows at small dams as well as Dwinnell Dam; diversion of spring flows for agriculture leading to warming of these waters during the critical summer months; loss of riparian vegetation; reduction of base flow through diversions and excessive pumping of ground water; and possible episodes of low oxygen concentrations. The Shasta River also shows loss of substrate characteristics consistent with successful spawning and has significant channel degradation associated with land-management practices. Practices leading to the degraded state of the Shasta include timber management, grazing, agriculture, and water management.

The Scott River also has high potential for restoration of coho salmon. Groundwater flows from springs are less pronounced than for the Shasta River, but an undesirable degree of cool water diversion occurs through groundwater pumping, as well as from surface diversions. Other problems closely parallel those of the Shasta, but physical degradation of the mainstem channel and lower tributaries may be even more pronounced than in the Shasta.

The Salmon River drains mainly public lands, but nevertheless shows historical reduction of coho and other salmon populations. Degradation of the Salmon River is primarily physical, and is associated with inadequate forest management leading to catastrophic fires and logging practices, especially road construction and maintenance, that lead to high levels of erosion. In addition, there are some flow barriers on the Salmon River.

The Trinity River, which is much larger than the other three tributaries, shows the full complex of problems found in the Scott and Shasta rivers, but is especially affected by loss of habitat caused by installation of dams and by physical damage to channels caused by improper land-management practices. Implementation of actions called for in the Record of Decision will promote restoration and create a framework for adaptive management through a large, comprehensive effort, but this effort must be coordinated with management of the overall Klamath basin.

Small tributaries to the four large tributaries and to the Klamath main stem show a wide array of problems and will require treatment by category or individually for effective restoration. Emphasis on cold water bearing tributaries is likely to yield the most benefit for salmonid restoration.

While the Klamath main stem is less important for rearing of coho than to some other anadromous taxa on the Klamath, a number of actions on the main stem might promote the welfare of coho. Additional water during the smolt migration could enhance downstream movement, and could be tested in this respect through adaptive management procedures. In addition, removal of Iron Gate Dam and Dwinnell Dam could open new habitat, especially by making available tributaries that are now are completely blocked to coho.

Application of computer modeling to habitat availability on the main stem is not likely to be relevant to coho, but would be relevant to other taxa, such as fall-run Chinook, that use the main stem extensively for rearing. In general, coho restoration requires increased attention to lands and waters beyond the Klamath Project.

Hatchery operations may have a suppressive effect on coho salmon through predation and competition; it should not be assumed that hatchery operations are beneficial to salmonids in general or to coho in particular. Hatchery operations could be viewed as adjustable rather than static and thus explored through adaptive management principles.

Because land-management practices are broadly responsible for degradation of habitat that is critical to the coho, improvement of land-management practices and restoration activities in tributary waters are the key to restoration of coho populations. Restoration will require extensive work with private parties and with agencies that are not now strongly involved in ESA actions. Restoration can succeed only through substantial technical assistance in support of the considerable private efforts that are now underway. Constant evaluation of the success of specific strategies will be important to their ultimate success.

A framework for overall management of fisheries exists already through interlocking federal statutes that require conservation and protection of habitat and fishes. The Sustainable Fisheries Act of 1996 in particular seems well suited as a model for management of environmental remediation in the Klamath basin.

9

Regulatory Context: The Endangered Species Act

Although the federal Endangered Species Act (ESA) is not alone in providing a legal framework for resolving issues related to endangered and threatened fishes in the Klamath River basin, it is the dominant legal feature now affecting federal water management in the basin. As the nation's principal federal law to protect species, the ESA's express purpose is "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved" (16 U.S.C. 1531(b) [2002]). Further explanation is provided in the statute's definition of "conserve," which is "to use … all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this chapter are no longer necessary" (16 U.S.C. 1532 [2002]). It is also a policy of the ESA, however, that "Federal agencies shall cooperate with State and Local agencies to resolve water resource issues in concert with the conservation of endangered species" (16 U.S.C. 1531(c) [2002]). The difficulty of satisfying those two central objectives is well illustrated by the Klamath River basin, as attested by the U.S. Bureau of Reclamation's (USBR) Klamath Project and other public and private water-management practices. Accordingly, this chapter provides an overview of the ESA and discusses the structure and implementation of its provisions that are relevant to the Klamath River basin generally and the Klamath Project in particular. The chapter provides conclusions as to how the ESA could be implemented more productively for the benefit of species and ecosystems in the Klamath River basin.

OVERVIEW OF THE ESA IN THE KLAMATH CONTEXT

In 1988, pursuant to its authority under Section 4 of the ESA, the U.S. Fish and Wildlife Service (USFWS) listed the shortnose sucker and Lost River sucker as endangered species (53 Fed. Reg. 27130, July 18, 1988). Almost a decade after the sucker listings, in 1997, the National Marine Fisheries Service (NMFS) listed the Southern Oregon/Northern California Coast (SONCC) coho salmon, an evolutionarily significant unit (ESU) of coho salmon found in the Klamath River basin, as a threatened species (62 Fed. Reg. 24588, May 6, 1997). These listings triggered a suite of ESA regulatory responsibilities that have since had substantial influence in Klamath River basin water issues:

- Section 4 of the ESA requires the listing agency to designate "critical habitat" for endangered and threatened species unless exceptions, which are narrow, apply.
- Section 4(f) of the ESA requires the listing agency to develop and implement a "recovery plan" for endangered and threatened species.
- Section 7(a)(1) of the ESA requires all federal agencies, through consultation with the listing agency, to use their authorities to carry out programs for the "conservation" of endangered and threatened species.
- Section 7(a)(2) of the ESA requires all federal agencies, through consultation with the listing agency, to ensure that actions they carry out, fund, or authorize do not "jeopardize" the continued existence of endangered and threatened species and do not result in "adverse modification" of their critical habitat.
- Section 9(a)(1) of the ESA prohibits all persons subject to U.S. jurisdiction (including federal, state, tribal, and local governments) from "taking" endangered wildlife species—and Section 4(d) allows the listing agency to extend the same level of protection to threatened wildlife species—unless authorized by the listing agency pursuant to appropriate "incidental take authorization" provisions of the ESA.

For reasons described more fully below, some of these responsibilities have not been implemented to their full potential in the Klamath River basin. USFWS and NMFS have used ESA's authority primarily through Section 7(a)(2), which prohibits federal agencies from causing "jeopardy" to listed species. Thus, the listing agencies have focused primarily on USBR's operation of the Klamath Project.

Before proceeding to a section-by-section comparison of ESA implementation in the Klamath River basin, it is important to recognize the pervasive influence of three general principles of ESA law and policy: the "best available evidence" standard, the burden of proof applicable to the relevant decision-makers, and the species-specific orientation of the ESA. As a package, these principles substantially affect the agencies' implementation of ESA duties and authorities under specific ESA provisions and their approach to the larger challenge of ecosystem-level management of resources in the Klamath River basin. Emphasizing the general principles also helps to clarify the distinctions between the framework within which the agencies operate under the ESA and the framework within which the NRC Committee evaluated the relevant agency decisions as defined by its charge.

The "Best Available Evidence" Standard

USFWS and NMFS have ESA decision-making duties, such as listing of species under Section 4 and issuance of biological opinions under Section 7, for which they must use the "best scientific and commercial data available" as prescribed in 16 USC 1533(b) [2002] and 50 CFR 424.11(b) [2002] (listing decisions) and 16 USC 1536(b) 2002 and 50 CFR 402.14(g)(8) [2002] (consultations). Section 7 thus requires that NMFS and USFWS consult the existing body of the "best scientific and commercial data available" to determine whether USBR's proposed operation of the Klamath Project is "likely to jeopardize the continued existence of any endangered species or threatened species."

Although the statute leaves the standard for "best evidence" undefined, the courts have interpreted it to mean several things:

- The agencies may not manipulate their decisions by unreasonably relying on some sources to the exclusion of others.
- The agencies may not disregard scientifically superior evidence.
- Relatively minor flaws in scientific data do not render the data unreliable.
- The agencies must use the best data *available*, not the best data *possible*.
- The agencies must rely on even inconclusive or uncertain information if that is the best available at the time of the decision.
- The agencies cannot insist on conclusive data to make a decision.
- The agencies are not required to conduct independent research to improve the pool of available data.

A summary of the existing body of case law appears in *Southwest Center for Biological Diversity v. Norton*, 2002 WL 1733618 (D.D.C. 2002).

Similarly, in 1994, USFWS and NMFS issued a joint policy providing guidelines for ESA decisions (59 Fed. Reg. 34271 [1994]). The policy shows how the "best evidence" standard would apply in the context of the jeopardy consultation; it directs the agencies to follow six guidelines:

- Require that all biologists evaluate all scientific and other information that will be used to make any consultation decision.
- Gather and impartially evaluate biological, ecological, and other information that disputes official positions taken by USFWS or NMFS.
- Ensure that biologists document their evaluation of information that supports or does not support a position being proposed by the agency.
- Use primary and original sources of information, when possible, as the basis of consultation decisions or recommendations.
- Adhere to schedules established by the ESA.
- Conduct management-level review of documents developed by the agency to verify and ensure the quality of the science used to established official positions.

Appropriately, therefore, the charge of the NRC committee included a determination as to "whether the biological opinions are consistent with the *available* scientific information" (emphasis added).

The Decision-Making Burden of Proof

The NRC Committee's charge to assess "whether the [agencies'] biological opinions are consistent with the available scientific information" requires the committee to adopt the burden of proof that would apply in the scientific community rather than the legal burden of proof that applies under the ESA. Scientific burden of proof may differ from legal burden of proof; this issue pervades the ESA, where science and law intersect. Keeping scientific and legal burdens of proof separate is important for proper execution of the committee's charge. The committee believes that in its interim report and in this final report it has applied an accepted scientific framework for its assessment.

Some parties to the Klamath River basin ESA actions have advocated use of a "precautionary principle," according to which a special burden of proof lies with users of resources (e.g., G. H. Spain, Pacific Coast Federation of Fisherman's Associations, personal communication, August 26, 2002). The precautionary principle, however, is a decision-making policy instrument, not a scientific standard of proof or a requirement of the ESA. Although many versions of the precautionary principle exist in the laws of many nations and in the text of many international treaties, the prototype is found in Principle 15 of the 1992 Rio Declaration of the United Nations Conference on Environment and Development (Rio Declaration on Environment and Development, UNCED, U.N. Doc. A/CONF.151/Rev. 1, 31 I.L.M. 874 [1992]):

> In order to protect the environment, the precautionary approach shall be widely applied by the States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

In other words, ignorance should not justify the decision either to move forward with a proposed action that might threaten the environment or to not regulate an activity for purposes of protecting the environment.

Application of the precautionary principle in the ESA context is discussed in the National Research Council's report *Science and the Endangered Species Act* (NRC 1995), which outlines the benefits of applying such an approach to decisions about conservation of species under the ESA. As that discussion demonstrates, however, whether to apply the precautionary principle is a policy decision and as such is outside the present committee's scope of work, which pertains to "whether the biological opinions are consistent with the available scientific information."

Indeed, even when a policy decision is made to apply the precautionary principle, the question of whether the decision is consistent with the available scientific information is important. As discussed above, the ESA and the agencies' implementing regulations unequivocally require that NMFS and USFWS base their decisions, as given in their biological opinions, on the *best available* scientific evidence and that NMFS and USFWS use that evidence to decide whether Klamath Project operations are *likely* to jeopardize the listed species. These are the only explicit evidentiary standards and burdens of proof that the ESA and the agency regulations impose on the two agencies in the consultation process. In the decision-making context, relevant principles of administrative law and the ESA leave application of the precautionary principle to the discretion of USFWS and NMFS when they are confronted with substantial but inconclusive or conflicting data, especially as to whether a species deserves listing or whether a proposed action is likely to cause jeopardy (see *Conner v. Burford*, 848 F.2d 1441, 1454 9th Cir. [1988]). At some point, however, erring on the side of protection in decision-making ceases to be precautionary and becomes arbitrary. One indication that policy-based precaution has given way to bias or political forces is a major inconsistency of a presumed precautionary action with the available scientific information. Hence, the precautionary principle could not guide the NRC Committee's scientific evaluation; rather, the committee evaluated the way in which NMFS and USFWS considered the best available scientific information and how they used this information to decide whether USBR's proposed operation of the Klamath Project is likely to jeopardize the continued existence of the endangered suckers and threatened coho salmon. In making this evaluation, the NRC Committee recognized that scientists of federal agencies who are responsible for judging jeopardy to listed species inevitably face difficulties that derive from incomplete information even under the best of circumstances, and certainly so in the case of the Klamath basin.

The Species-Specific Orientation of the ESA

The portion of the committee's charge requiring it to evaluate "whether the biological opinions are consistent with the available scientific information" implicates one of the inherent limiting features of the ESA: it is species-specific. The biological opinions under study, therefore, are opinions about listed species and not directly about the effects of the Klamath Project on resources in the Klamath River basin that have no known linkage to listed species. Notwithstanding its stated purpose of conserving the ecosystems on which listed species depend, the ESA is strikingly short on ecosystem-focused rationale. The ESA authorizes USFWS and NMFS to list species, to designate critical habitat for species, to prepare recovery plans for species, to use authorities for conservation of species, and to issue incidental-take authorizations for species. The ESA prohibits federal agencies from jeopardizing species, and it prohibits all others (including individuals and private organizations) from taking species. Indeed, the NRC Committee's charge has been conditioned by the ESA's species-specific focus, with the ultimate objective of providing "an assessment of scientific considerations relevant to strategies for promoting the recovery of listed species in the Klamath River Basin" (Appendix A).

As shown in previous chapters of this report, the listed species do not define all there is to manage in the basin; their needs encompass only a portion of the Klamath basin's combined environmental resources. In fact, a species-specific focus and an ecosystem-level focus may lead to different management policies and decisions (NRC 1995, p. 111-121). Often, actions that restore ecosystem functions are beneficial to listed species, but not always. Conversely, what is good for the listed species is not necessarily good for other ecosystem attributes or, for that matter, equally beneficial for all the listed species themselves. The dichotomy between the listed species and ecosystems limits the extent to which USFWS and NMFS can use the ESA for ecosystem management (Ruhl 2000). The ESA's species-specific focus is in itself an inadequate basis of ecosystem-wide decision-making in the Klamath River basin.

SPECIES LISTING AND DESIGNATION OF CRITICAL HABITAT

None of the conservation measures of the ESA that bear on the Klamath River basin apply unless a species is listed as endangered or threatened according to procedures specified in

Section 4 of the statute. A related decision, although not necessarily made at the time of listing (or, in some cases, at all), is whether the species has "critical habitat" that should receive special protection. Listing of species and critical-habitat designations thus are the events that trigger the ESA's recovery-planning efforts and regulatory programs. A review of the background of the Klamath River basin species listings and critical-habitat determinations shows the potential and realized scope of the recovery-planning efforts and regulatory programs that have followed.

Listing of Endangered and Threatened Species

Section 4 of the ESA governs listing of species as endangered or threatened. A species is endangered if it "is in danger of extinction throughout all or a significant portion of its range" and is threatened if it "is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range" (16 U.S.C. 1532 [2002]). The agencies must consider five criteria in listing a species: the present or threatened destruction, modification, or curtailment of its habitat or range; its overuse for commercial, recreational, scientific, or educational purposes; disease or predation; the inadequacy of existing regulatory mechanisms; and other natural or anthropogenic factors affecting its continued existence (16 U.S.C. 1533(a)(1)(A)-(E) [2002]). As noted above, the agencies must evaluate these criteria for the species in question and make the listing determination "solely on the basis of the best scientific and commercial data available … after conducting a review of the status of the species." This limitation keeps USFWS or NMFS from considering economic factors in deciding whether to list a species.

USFWS listed the two sucker species as endangered in 1988, noting that "dams, draining of marshes, diversion of rivers and dredging of lakes have reduced the range and numbers of both species by more than 95 percent…. Both species are jeopardized by continued loss of habitat, hybridization with more common closely related species, competition and predation by exotic species, and insularization of remaining habitats" (53 Fed. Reg. 27130 [1988]). The agency explained some of the principal factors causing decline in amount of habitat, as given in Chapters 5 and 6.

NMFS, in listing the coho salmon as a threatened ESU in 1997, found that "threats to this ESU are numerous and varied. Several human caused factors, including habitat degradation, harvest, and artificial propagation, exacerbate the effects of natural environmental variability brought about by drought, floods, and poor ocean conditions" (62 Fed. Reg. 24588 [1997]). The agency also explained in more detail the major factors responsible for the decline of coho salmon in Oregon and California (Chapters 7 and 8).

Designation of Critical Habitat

Section 4 of the ESA also requires USFWS and NMFS, subject to specified exceptions, to designate the critical habitat of a listed species. Critical habitat consists of "the areas within the geographical area occupied by the species, at the time it is listed … on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection" (16 U.S.C 1531 [2002]). Areas outside the occupied area can be included if they are essential to the conservation of the species. USFWS and NMFS, in making the critical-habitat determination, consider space for individual and population growth and for normal behavior; food, water, air, light, minerals, or other nutritional or physiological requirements; cover or shelter; sites for breeding, reproduction, rearing of offspring, germination, or seed dispersal; and habitats that are protected from disturbance or are representative of the historic geographic and ecological distributions of a species (50 C.F.R. 424.12(b)(1)-(5) [2002]). In weighing these factors, the agencies focus on "primary constituent elements," which are "roost sites, nesting grounds, spawning sites, feeding sites, seasonal wetland or dryland, water quality or quantity, host species or plant pollinator, geological formation, vegetation type, tide, and specific soil types." The agencies must consider the factors "on the basis of the best scientific and commercial data available" but must also take "into consideration the economic impact, and any other relevant impact, of specifying any particular area as critical habitat" (16 U.S.C. 1533(b)(2) [2002]). Areas that otherwise satisfy the criteria for critical habitat must be excluded from designation if the costs of designation outweigh the benefits of including the area, unless failure to designate such an area would result in the extinction of the species.

The agencies are required to designate critical habitat, to the greatest extent prudent and determinable, concurrently with the listing decision (16 U.S.C. 1533(a)(3) [2002]). The time period for a designation may be extended up to 1 yr if the agency finds either that publishing the listing rule has high priority for conservation of the species or that critical habitat is not determinable at the time of listing. In such a case the agency must designate critical habitat within the 1-yr extension period "to the maximum extent prudent" (16 U.S.C. 1533(b)(6)(C) [2002]). Accordingly, the agency can find that designating critical habit is "not prudent" and thus decline to do so.

Treatment of the "economic impacts" and the "not prudent" components of critical-habitat requirement by the agencies has been the subject of intense litigation in recent years; several judicial opinions have found the agencies' approaches flawed. For the analysis of economic impacts, the agencies have taken the position that the combined legal (and thus economic) effects of jeopardy consultations under Section 7(a)(2) and of the take prohibition under Section 9(a)(1), both of which apply when a species is listed and do not require designation of critical habitat to take effect, subsume any regulatory effects that critical-habitat designation might impose. Thus the incremental economic impact of designating critical habitat is, according to the agencies, essentially nil. Adopting this position as an assumption for purposes of analyzing economic impacts has allowed the agencies to truncate the process: although economic effects were never actually quantified, the agencies took the baseline effects imposed under the jeopardy consultation and the take prohibition as the starting point for economic analysis of the effects of critical-habitat designation. The agencies thus avoided having to describe the baseline effects and routinely found—with relatively little analytic exercise, given their operating assumptions—that the incremental effects of critical-habitat designation were zero. In 2001, however, a court ruled that the agencies' approach subverted congressional intent; the court required the agency in question to quantify both the baseline effects and any incremental effects (see *New Mexico Cattle Growers Association v. USFWS*, 248 F.3d 1277, 10th Cir. [2001]).

Similarly, on the "not prudent" question, the agencies had taken the position that because designation of critical habitat triggers only the prohibition against federal agencies' adversely modifying critical habitat, it adds relatively little protection, if any, to what is already available to listed species under the jeopardy consultation and prohibition against take. Designation of critical habitat, the agencies also argued, could be detrimental to species by identifying places where unscrupulous collectors might find the species. On balance, the agencies often found that detriments associated with designation of critical habitat outweighed benefits and that a designation of critical habitat was "not prudent." This set of assumptions also has been rejected by courts in recent years on the grounds that designation of critical habitat has important educational effects at least and that Congress did not intend it to be avoided through the blanket assumptions that the agencies have adopted (see *Sierra Club v. USFWS*, 245 F.3d 434, 5th Cir. [2001]). Notwithstanding the assumptions that have prevailed in the agencies' implementation of critical-habitat rules, USFWS has proposed critical habitat for the suckers, and NMFS has done the same for the coho salmon (Chapters 5-8).

In its 1988 rule listing the suckers, USFWS declined to designate critical habitat, because "little additional benefits of notification of the species presence would be achieved through critical habitat designation" (53 Fed. Reg. 27132 [1988]). Later, however, USFWS proposed critical habitat for the species (Chapter 6; 59 Fed. Reg. 61744 December 1, 1994), but it has not promulgated a final ruling on critical habitat for the suckers, probably because of general litigation over the manner in which USFWS has implemented decisions on critical habitat. It is not clear what effect some of the recent judicial opinions on critical habitat would have on the designation of critical habitat for the listed suckers, because the analysis of economic impacts has not been developed, contrary to some judicial requirements.

In its 1997 rule listing the salmon, NMFS found that "critical habitat is not determinable at this time" and that the species should be listed before the decision on critical habitat was finalized (62 Fed. Reg. 24608 [1997]). The agency did, however, designate critical habitat for the species in 1999 (64 Fed. Reg. 24049 May 5, 1999). It adopted a watershed-based approach to the designation (64 Fed. Reg. 24052 [1999]), explaining that

> a more inclusive, watershed-based description of critical habitat is appropriate because it (1) recognizes the species' use of diverse habitats and underscores the need to account for all of the habitat types supporting the species' freshwater and estuarine life stages, from small headwater streams to migration corridors and estuarine rearing areas; (2) takes into account the natural variability in habitat use that makes precise mapping problematic (e.g., some streams may have fish present only in years of plentiful rainfall); and (3) reinforces the important linkage between aquatic areas and adjacent riparian/upland areas. While unoccupied streams are excluded from critical habitat, NMFS reiterates the proposed rule language that "it is important to note that habitat quality in this current range is intrinsically related to the quality of upland areas and of inaccessible headwater or intermittent elements (e.g., large woody debris, gravel, water quality) crucial for coho in downstream reaches."

Significantly, NMFS included riparian zones in the designation because "streams and stream functioning are inextricably linked to adjacent riparian and upland (or upslope) areas" (64 Fed. Reg. 24053 [1999]). NMFS also explained (64 Fed. Reg. 24059 [1999]) that

> activities that may require special management considerations for freshwater and estuarine life stages of listed coho salmon include, but are not limited to (1) land management; (2) timber harvest; (3) point and non-point water pollution; (4) livestock grazing; (5) habitat restoration; (6) beaver removal; (7) irrigation water withdrawals and returns; (8) mining; (9) road construction; (10) dam operation and maintenance; (11) diking and streambank stabilization; and (12) dredge and fill activities.

It is not clear what effect some of the recent judicial opinions on critical habitat would have on the NMFS ruling for coho salmon, because the analysis of economic impacts has not been developed.

Recovery Planning

Section 4(f) of the ESA provides that, on listing a species, USFWS or NMFS "shall develop and implement plans (hereinafter in this subsection referred to as 'recovery plans') for the conservation and survival of endangered species and threatened species listed pursuant to this section, unless [the agency] finds that such a plan will not promote the conservation of the species" (16 U.S.C. 1533(f) [2002]). Recovery plans are to include a description of site-specific management actions that may be necessary for the conservation and survival of the species and objective, measurable criteria that, when met, would result in a determination that the species be removed from the list.

Despite the requirements of Section 4(f), recovery plans do not constitute mandatory directives to USFWS, NMFS, other federal agencies, or others. USFWS and NMFS portray them as guidelines and useful menus of recovery-oriented actions that they and other parties can take voluntarily. The courts have rejected efforts to instill more legal effect into the recovery-plan program (Cheever 2001).

NMFS has prepared no formal recovery plan for the coho salmon. In contrast, USFWS finalized a formal recovery plan for the endangered sucker species on March 17, 1993. As explained in Chapter 6, the NRC Committee believes that the sucker recovery plan contains many constructive recommendations but may need revision in view of extensive research efforts since 1993.

Regulatory Consequences

Only when a species is listed do the regulatory programs of the ESA come into play. Two of them apply directly only to federal agencies: the so-called conservation duty under Section 7(a)(1), and the duty under Section 7(a)(2) to avoid jeopardizing species or adversely modifying critical habitat. Section 7(a)(2), however, can have substantial indirect effects on state, tribal, and local governments and private entities that receive federal funding or approvals or that benefit from federal actions. The third major regulatory program, the take prohibition of Section 9(a)(1), applies directly to all entities—federal, state, tribal, and local governments and all private entities.

Federal Agency Conservation Duty

Section 7(a)(1) of the ESA states that "all federal agencies shall, in consultation and with the assistance of [USFWS and NMFS], utilize their authorities in furtherance of the purposes of this chapter by carrying out programs for the conservation of endangered species and threatened species" (16 U.S.C. 1536(a)(1) [2002]). This duty, however, is poorly defined. No procedures are specified in the ESA, nor have USFWS and NMFS provided any in their regulations.

The courts generally have construed the provision to require federal agencies to take affirmative action or to restrain from negative action to advance the purpose of conservation (Ruhl 1995). In addition, courts have confirmed that Section 7(a)(1) is a source of authority for an agency to take action in support of species conservation where no other provision of the ESA requires it, as long as the action is within the scope of and not in conflict with the agency's authority under its enabling statutes. As explained below, Sections 7(a)(2) and 9(a)(1) are prohibitions: Section 7(a)(2) prohibits federal agencies from jeopardizing species or adversely modifying critical habitat, whereas Section 9(a)(1) prohibits federal agencies from causing take (mortality or impairment). Failure of an agency to undertake actions that would promote conservation of species often would be consistent with these prohibitions. In contrast, Section 7(a)(1) is an affirmatively stated duty to promote conservation of species, and thus can serve as authority for taking actions that neither Section 7(a)(2) nor Section 9(a)(1) would require (see *Carson-Truckee Water Conservancy District v. Watt*, 549 F. Supp. 704, D. Nev. 1982, aff'd 741 F.2d 257, 9th Cir. [1984]). For example, USBR could restrict water deliveries to protect endangered fish, even though it is not required to do so under Section 7(a)(2) or 9(a)(1), because of Section 7(a)(1).

USFWS, NMFS, and other federal agencies carrying out their responsibilities in the Klamath River basin have not taken full advantage of their authority under Section 7(a)(1). For example, USBR explained in its 2002 biological assessment for the Klamath Project that Section 7(a)(1) does not expand the agency's authority beyond its enabling laws. On the basis of that principle, USBR made no additional effort to exercise its authority under Section 7(a)(1). As described above, however, Section 7(a)(1) essentially states that actions by agencies that are consistent with enabling laws and that are intended to provide for the conservation of species cannot be challenged just because they are not required by Section 7(a)(2) or 9(a)(1). Hence, the provision creates an opportunity for conservation-promoting actions under the ESA beyond the mandates of Sections 7(a)(2) and 9(a)(1). Many of the actions outlined in this report for conservation of the listed suckers and coho salmon would be supported by Section 7(a)(1), even though they might not be required by Section 7(a)(2) or 9(a)(1). In other words, USFWS, NMFS, and all other federal agencies carrying out actions in the Klamath River basin have substantial discretion to act on behalf of the listed species even where they do not have the duty to do so.

Section 7(a)(1) clearly does require that all relevant federal agencies at the very least consult with USFWS and NMFS about the exercise of discretionary authority (see *Sierra Club v. Glickman*, 156 F.3d 606, 5th Cir. [1998]). Unlike consultation under Section 7(a)(2), which has been the context for most ESA implementation measures in the Klamath River basin, consultation under Section 7(a)(1) is not governed by formal procedures. Working together, the agencies could establish and implement a comprehensive, flexible, multiagency consultation process that is directed specifically at the Klamath River basin and is designed to specify actions that each agency could take, under and consistent with its general authorities, to promote conservation of the listed species. In implementing such actions, agencies would be protected from legal challenge by their authority under Section 7(a)(1).

A substantial effort, justified under Section 7(a)(1), should be made to enlist all federal agencies operating in the Klamath River basin in recovery efforts. In fact, the relevant agencies—which include USFWS, NMFS, USBR, the U.S. Forest Service, and the U.S. Army Corps of Engineers—in 1994 jointly affirmed their Section 7(a)(1) authority and agreed to "identify opportunities to conserve Federally listed species and the ecosystems upon which those species depend" (Memorandum of Agreement 1994). Each of these agencies also agreed to "determine whether its respective planning processes effectively help conserve threatened and endangered species and the ecosystems upon which those species depend" and to "use existing programs, or establish a program if one does not currently exist, to evaluate, recognize, and reward the performance and achievements of personnel who are responsible for planning or implementing programs to conserve or recover listed species or the ecosystems upon which they depend." Yet there is little evidence that any federal agency operating in the Klamath River basin has been successful in fulfilling these agreements in the context of the ESA.

In summary, a multiagency consultation process under Section 7(a)(1) could expand recovery efforts beyond USBR and its Klamath Project, as needed ultimately for recovery. Section 7(a)(1) does not require any agency participating in the consultation to implement particular measures; only institutional will can bring that about. But if ever a case existed for motivating institutional will in this direction, the Klamath River basin fits the description.

PROHIBITION AGAINST JEOPARDY AND ADVERSE MODIFICATION CAUSED BY FEDERAL AGENCIES

Section 7(a)(2) of the ESA requires (16 U.S.C. 1536(a)(2) 2002) that

> each federal agency shall, in consultation with and with the assistance of [USFWS and NMFS], insure that any action authorized, funded, or carried out by such agency (hereinafter in this section referred to as an "agency action") is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species which is determined … to be critical.

The Klamath Project is subject to this requirement (see *Klamath Water Users Protection Ass'n v. Patterson*, 191 F.3d 1115, 9th Cir. 1999; *O'Neil v. United States*, 50 F.3d 667, 9th Cir. [1995]). The ESA provides an elaborate set of procedures and criteria for carrying out the jeopardy and adverse modification consultations (16 U.S.C. 1536(b)-(d) [2002]). USFWS and NMFS also have issued an extensive set of regulations covering the process (50 C.F.R. part 402 [2002]). Generally, the action agency must prepare a "biological assessment" detailing the effects that it believes its actions will have on listed species, and the consulting agency (USFWS or NMFS) must in response provide a "biological opinion" declaring whether jeopardy and adverse modification are likely to occur. If the consulting agency finds that jeopardy will occur, it must suggest "reasonable and prudent alternatives" (RPA) by which the action agency can avoid such an outcome. The RPAs, technically within the discretion of the action agency to accept or reject (see *Southwest Center for Biological Diversity v. Bureau of Reclamation*, 143 F.3d 515, 9th Cir. [1998]), carry considerable weight and are viewed as essentially mandatory in the absence of some compelling basis that the action agency might have for using different alternatives (see *Bennett v. Spear*, 520 U.S. 154 [1997]).

All agencies must fulfill all the duties by using "the best scientific and commercial data available" (50 C.F.R. 402.14(d) and 402.14(g)(8) [2002]). Action agencies also must ensure that they and their license or permit applicants "shall not make any irreversible or irretrievable commitment of resources with respect to the agency action which has the effect of foreclosing the formulation or implementation of any reasonable and prudent alternatives" (16 U.S.C. 1536(d) [2002]). A procedure established in the ESA—but rarely used, given its narrow criteria—allows an action agency to appeal a jeopardy or adverse modification finding to a committee of cabinet-level and other federal agency officials and thereby seek to carry out the action regardless of jeopardy or adverse modification (16 U.S.C. 1536(e)-(n) [2002]; 50 C.F.R. part 450 [2002]). Irrigation districts sought to initiate that procedure with respect to the 2001 jeopardy opinions that USFWS and NMFS issued for the Klamath Project, but in July 2001 the Department of the Interior declined to pursue the exemption process further. In addition to the jeopardy standards of Section 7(a)(2), the criteria for exemption involve policy matters outside the scope of this report.

The procedural details of the consultation process are not relevant to the NRC Committee's charge. Rather, the key aspects of the consultation program for the committee's purposes are the meanings of *jeopardy* and *reasonable and prudent alternative*, because both USFWS and NMFS made jeopardy findings in their 2001 biological opinions and because the RPAs that they presented led USBR to suspend water deliveries in 2001. The statute defines neither term. Under USFWS and NMFS regulations, *jeopardize the continued existence* means "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 C.F.R. 402.02 [2002]). *Reasonable and prudent alternative* means "alternative actions identified during formal consultation that can be implemented in a manner consistent with the intended purpose of the action, that can be implemented consistent with the scope of the Federal agency's legal authority, that is economically and technologically feasible, and that [USFWS or NMFS] believes would avoid the likelihood of jeopardizing the continued existence of listed species or resulting in the destruction or adverse modification of critical habitat" (50 C.F.R. 402.02 [2002]). Judgments of jeopardy are inherently difficult in a technical sense. Site-specific evidence must be used as extensively as possible in making such judgments, but use of professional judgment where site-specific evidence is inadequate or absent is inevitable and desirable for rational judgments of jeopardy (see Chapter 1).

As described in Chapter 1, USFWS has consulted with USBR regarding the Klamath Project's effects on the listed sucker species, and NMFS has done so for the coho salmon. The history of the consultations is long and has at times been controversial (see, e.g., *Bennett v. Spear*, 5 F.Supp.2d 882 D. Or. [1998]; *Pacific Coast Federation of Fishermen v. Bureau of Reclamation*, 138 F.Supp.2d 1228 N.D. Cal. [2001]). For consistency with its charge, the NRC Committee's principal focus has been on the 2001 and 2002 consultation documents.

In addition to the Klamath Project, numerous other actions in the Klamath River basin are carried out, funded, or authorized by federal agencies (Chapter 2). USFWS and NMFS do not appear to maintain comprehensive inventories of actions for which consultation is necessary and for which each action agency's consultation is satisfied or deficient, nor is there any basinwide strategy for conservation of the species through coordinated Section 7(a)(2) consultations. The agencies should prepare and implement such an inventory and strategy.

The Authorities to Prohibit Take and Incidental Take

Section 9(a)(1) of the ESA provides that "with respect to any endangered species of fish or wildlife … it is unlawful for any person subject to the jurisdiction of the United States to… take any such species within the United States or the territorial sea of the United States" (16 U.S.C. 1538(a)(1) [2002]). Although threatened species, such as the coho salmon, are not covered directly in this provision, Section 4(d) of the ESA provides that USFWS and NMFS "may by regulation prohibit with respect to any threatened species any act prohibited under section 1538(a)(1) of this title … with respect to endangered species" (16 U.S.C. 1533(d) [2002]).

Under the statute, to *take* is to "harass, harm, pursue, hunt, shoot, wound, trap, capture, or collect, or to attempt to engage in any such action" (16 U.S.C. 1532 [2002]). USFWS and NMFS have further defined *harm* to mean "an act which actually kills or injures wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering" (50 C.F.R. 17.3 [2002]). The U.S. Supreme Court has upheld the latter definition as consistent with the congressional intent of the ESA but in so ruling construed the regulation to limit findings of harm to cases in which actual death or injury to identifiable members of a protected species is the proximate and foreseeable result of a habitat modification (*Babbitt v. Sweet Home Chapter of Communities for a Great Oregon*, 515 U.S. 687 [1995]).

When USFWS and NMFS prepare biological opinions in connection with consultations under Section 7(a)(2) of the ESA, they most often find that no jeopardy or adverse modification will occur. Even in such cases, however, incidental take of a species might be a foreseeable consequence of the action. In such instances the consulting agency must (16 U.S.C. 1536(b)(4) [2002])

> provide the Federal agency and the applicant concerned, if any, with a written statement that (i) specifies the impact of such incidental take on the species, (ii) specifies those reasonable and prudent measures that the Secretary considers necessary or appropriate to minimize such impact, (iii) in the case of marine mammals, specifies those measures that are necessary to comply with section 1371(a)(5) of this title with regard to such taking, and (iv) sets forth the terms and conditions (including, but not limited to, reporting requirements) that must be complied with by the Federal agency or applicant (if any), or both, to implement the measures specified under clauses (ii) and (iii).

A similar procedure for authorization of incidental take is available under Section 10(a)(1)(B) of the ESA for projects and actions not carried out, funded, or authorized by a federal agency and thus not subject to the consultation requirement of Section 7(a)(2). Under the procedure, the entity carrying out an action that will cause take of a listed species must submit a habitat conservation plan (HCP) to USFWS or NMFS on which the agency bases its decision of whether to grant a permit for the incidental take (16 U.S.C. 1539(a)(1)(B) [2002]).

USFWS and NMFS consistently have found in their biological opinions for the Klamath Project that USBR's actions will result in take of the species in question and have prepared incidental-take statements with reasonable and prudent measures and terms and conditions for implementing them. Some take of the listed species is an undisputed consequence of USBR's operation of the Klamath Project (see Chapters 6 and 8), and the reasonable and prudent measures for avoiding this take are well founded. One concern of the NRC Committee, however, is the lack of attention that USFWS and NMFS appear to have given to take of the listed species by actions other than USBR's operation of the Klamath Project. Throughout the Klamath River basin, actions by public and private entities are causing take of the listed species. Many of these actions are outside the control of the USBR and thus not susceptible to correction though the Klamath Project consultations. Such sources of take, which the committee believes may be substantial, should not be ignored simply because USBR and the Klamath Project present a bigger and easier target for consultation. Indeed, doing so leads inevitably to the potential for overregulation of the Klamath Project and, indirectly, its beneficiaries and thus an inequitable distribution of the social and economic costs of the conservation of species. The Klamath Project is a valid target for scrutiny and regulation, but not the only one.

Examples of take outside the reach of the Klamath Project are given in the listing documents and in Chapters 5-8 of this report. For example, Chiloquin Dam causes take of endangered suckers but is not under the control of USBR in connection with the Klamath Project. Even so, there is no organized effort by USFWS to enforce the take prohibition at Chiloquin Dam or elsewhere outside the Klamath Project where persons causing take must modify their behavior so as to avoid take or submit HCPs under Section 10(a)(1)(B). NMFS has a similar record in relation to coho salmon. In other parts of the nation, however, such as Austin, Portland, Tucson, and southern California, USFWS and NMFS have expended considerable resources to limit incidental take of listed species caused by dispersed actions, including those of private parties. It is not clear why the agencies have not initiated similar enforcement actions in the Klamath River basin.

There is ample basis for each agency to extend its authority to prohibit take, and doing so is likely to benefit the listed species. For example, NMFS listed the coho salmon ESU as threatened, requiring the agency to adopt conservation regulations under Section 4(d) of the ESA, and thus to regulate take of the species. In July 1997, the agency published an interim Section 4(d) rule extending the full extent of Section 9(a) take prohibitions to the species, except for specified benign and beneficial actions, including aspects of habitat restoration programs that the states had initiated (62 Fed. Reg. 38479 July 18, 1997). In July 2000, the agency included the coho salmon in a rule establishing general take authorizations for specified activities, subject to limits, covering 14 salmonid ESUs (65 Fed. Reg. 42421 July 10, 2000).

When describing the activities that would be affected by the take prohibition in its July 1999 interim Section 4(d) rule for the coho salmon ESU, NMFS explained that "agricultural activities that might result in take of SONCC coho are ... sediment from cultivation or livestock movements on the banks or in the beds of streams; unscreened water diversions and reductions of flow through irrigation could also result in take; and NMFS … would expect the 4(d) rule to result in some curtailment of [timber] harvest on lands owned by small entities over and above the impacts of state regulation" (62 Fed. Reg. 38481-38483 [1997]). In the July 2000 rule, NMFS explained that the general take authorizations cover "properly screened water diversion devices" (62 Fed. Reg. 42423 [1997]). Other agricultural, logging, and land-use activities were not covered in any general or specific way by the general take authorizations.

As is the case for the listed sucker species, there clearly are numerous common activities outside the control of USBR that are recognized by NMFS as causing unauthorized take of coho salmon in the Klamath basin. NMFS recognized this in its 2002 biological opinion on the Klamath Project, for example, when it acknowledged that USBR accounts for 57% rather than 100% of the total irrigation-related depletions of flow at Iron Gate Dam. If, as NMFS has concluded, USBR's flow-depletion component has triggered jeopardy of the species, the other irrigation flow depletions most likely are also causing take of the species. Yet there is little evidence that NMFS has actively enforced the take prohibition in these contexts in the Klamath River basin (as it recently did, in contrast, against the Grants Pass Irrigation District for its take of salmon at its Savage Rapids Dam diversion structure). The NRC Committee has not examined the full extent of the potential measures that NMFS might take in enforcing the take prohibition in the Klamath basin beyond USBR's operation of the Klamath Project, but there is ample basis for the agency to do so, and doing so is likely to benefit the species (Chapter 8).

For take caused by the Klamath Project, USBR obtains approval through the procedure on incidental-take statements given in Section 7(b)(4). If USFWS and NMFS were faithfully to enforce the take prohibition, there would be many more additional nonproject actions that, if not modified to discontinue the take, also would require authorization of incidental take. Take of listed suckers and salmon caused by actions other than the Klamath Project may even be associated with some federal agency funding or approval, in which case Section 7(b)(4) also would apply. For take caused by actions not carried out, funded, or authorized by a federal agency, Section 10(a)(1) supplies the applicable procedure.

Given the multiplicity of actions that may be causing take of the listed suckers and salmon, it may be productive for representatives of various interests to consider organizing an effort to explore a regional HCP that would form the basis for USFWS and NMFS to issue an "umbrella" authorization of incidental take for several actions in the Klamath River basin. Regional HCPs have been used or explored in a number of urban and rural settings as a means of avoiding piecemeal administration of incidental take permitting and to enhance opportunities for more efficient and effective habitat conservation and mitigation measures (Thornton 2001). Moreover, like the Section 7(a)(1) multiagency consultation proposed above, the regional HCP process involves coordination of numerous diverse interests and thus has the potential to produce more sustainable decisions than would incremental, action-specific permitting. As an earlier National Research Council committee found (NRC 1995, p. 92, 198-199), "habitat conservation planning … has the potential to be effective in protecting ecosystems and has realized that potential in a few cases," leading it to "endorse regionally based, negotiated approaches to the development of habitat conservation plans."

NMFS appears to have recognized the benefits of such interest planning processes in its 2002 biological opinion when it recommended creation of a "task force" to address the 43% of irrigation-related flow depletion at Iron Gate Dam that is not attributable to USBR. The NRC Committee sees no reason why a Section 7(a)(1) process and a regional HCP process cannot be undertaken simultaneously and in coordination to fulfill the objectives of such a task force and of related species-conservation goals in the Klamath River basin.

CONCLUSIONS

The ESA is not a panacea for the challenges of ecosystem management and species conservation posed in the Klamath River basin. However, ESA authorities could be implemented more effectively, more extensively, and more creatively than they are now. Specifically, the relevant federal agencies have failed in several ways to exercise their full ESA authorities.

- USFWS and NMFS recovery planning for listed species under Section 4(f) has stalled.
- Federal agencies operating in the Klamath River basin have not been successful in the full use of discretionary conservation authority given in Section 7(a)(1).
- USFWS and NMFS appear to have focused jeopardy consultation under Section 7(a)(2) narrowly on USBR's operation of the Klamath Project, notwithstanding the many other federal agency actions carried out, funded, or authorized in or affecting the Klamath River basin. Neither agency has made any basinwide inventory of or strategy for federal actions and consultations a prominent part of its public discourse on the Klamath basin.
- USFWS and NMFS have not actively enforced the ESA Section 9 take prohibition outside the context of the Klamath Project itself, notwithstanding ample evidence that numerous other actions are causing take of the species.

Those problems in large part could be remedied as follows:

- NMFS could prepare and promulgate a recovery plan for the coho salmon, and USFWS could revise, update, and repromulgate the sucker recovery plan. In each case, the recovery plan could be designed with the specific purpose of enabling federal agency consultations under Sections 7(a)(1) and 7(a)(2) and individual or regional habitat-conservation planning under Section 10(a)(1), and it ideally would be capable of being carried out more comprehensively—

that is, across the full spectrum of issues in the Klamath River basin and not just the Klamath Project—and through adaptive-management principles.

- NMFS and USFWS could inventory all federal agencies that are exercising any authority in or affecting the Klamath River basin and could initiate a multiagency consultation process with them under Section 7(a)(1). The consultation process would be most effective if centered on adaptive-management principles. Each federal agency engaging in the process could direct its institutional will toward fulfilling the agreements it made in the 1994 interagency agreement regarding the exercise of discretionary authority under Section 7(a)(1), with the Klamath River basin specifically in mind.
- If they have not already done so, NMFS and USFWS could inventory all active and potential federal agency consultations that are or could be carried out in the Klamath River basin under Section 7(a)(2), and develop a more coordinated basin-wide approach to the entire package of consultations. If these instruments already exist, the agencies could use them more overtly and provide the public more information about them.
- NMFS and USFWS could identify the inventory of federal, state, local, tribal, and private actions that are causing unauthorized take of the suckers and coho salmon. NMFS and USFWS could work with the agencies and persons causing the takes to help them either to modify their behavior to avoid the takes or to obtain incidental-take authorization under Section 7(b)(4) or 10(a)(1). NMFS and USFWS could explore with those interests, which include private-sector and government actors, the possibility of a regional habitat-conservation planning approach.

10

Adaptive Management for Ecosystem Restoration in the Klamath Basin

This report has described many ways in which the status of Klamath basin ecosystems can be improved for the benefit of endangered or threatened species and other fish and wildlife resources. The report also shows that geographic expansion of restoration efforts beyond the lakes and the main stem of the Klamath River is necessary for recovery of listed species. Recovery efforts will require adjustments in policies of agencies, in cooperation between institutions, and human use of resources in the basin.

Ecosystem management in the Klamath basin today is disjointed, occasionally dysfunctional, and commonly adversarial. Thus, it often is inefficient or ineffective in dealing with issues related to restoration of listed species in the basin. Cooperation among agencies has been poor; potential restoration activities have been generally restricted to actions or operations of the Klamath Project; and local communities, stakeholders, and individuals that control resources critical to long-term solutions often have been alienated, uninterested, or simply left out. Changes that occurred during consultations leading to the biological assessment and opinions of 2002 appear to show some movement toward remedies for these deficiencies, but much remains to be done, and an overall integrated strategy still is missing.

This chapter discusses alternative or modified management frameworks that might allow resources for recovery to be used more effectively than in the past. First, the potential value of adaptive management is explored. The chapter then presents specific examples of policy instruments, approaches, and activities that may facilitate environmental restoration. The last section suggests specific changes in management that probably would improve the efficacy of public and private investments in habitat or minimize the costs to private landowners as they adjust to the needs of listed species.

ADAPTIVE MANAGEMENT AS AN ORGANIZING FRAMEWORK

Regional restoration programs—which typically are large, complex, and fraught with uncertainties and competing interests—must include a process for implementing restoration activities and a means of measuring their effectiveness. The concepts of adaptive assessment (analysis leading to adaptations) and adaptive management (adjustment of management in light of new information) are often suitable for those purposes; for brevity, they are referred to here collectively as adaptive management.

Adaptive management is a formal, systematic, and rigorous program of learning from the outcomes of management actions, accommodating change, and improving management (Holling 1978). Its primary purpose is to establish a continuous, iterative process for increasing the probability that a plan for environmental restoration will be successful. In practice, adaptive management uses conceptual and numerical models and the scientific method to develop and test management options. It requires the explicit recognition that management policies can, with appropriate precautions, be applied as experimental treatments (Walters 1997). Decision makers use the results as a basis for improving knowledge of the system and adjusting management accordingly (Haley 1990, McLain and Lee 1996).

Adaptive management is being applied to major ecosystem restoration projects in the Florida Everglades, Chesapeake Bay, and California's Sacramento and San Joaquin River system (CERP 2002, CALFED 2002), and it recently has been used in an evaluation of flow regimes for the Grand Canyon (NRC 1999) and the Trinity River component of the Klamath River system (USFWS/HVT 1999). The following description of the adaptive management process is drawn from the CALFED Sacramento-San Joaquin Comprehensive Study working paper (2002), the appendix to USFWS/HVT (1999), Nagle and Ruhl (2002), and other sources. Not all features of adaptive management will be applicable to the Klamath basin, given legal constraints arising from the federal Endangered Species Act (ESA; Chapter 9). The general principles of adaptive management do, however, provide useful guidance as managers consider development and implementation of recovery plans. Adaptive management on the Trinity River could serve as a useful model for the rest of the basin.

Ecosystem Management and Adaptive Management

Ecosystem management refers to policy goals directed at ensuring the sustainability of natural resources in ecologically functional units (Grumbine 1994). Grumbine defines *adaptive management* as a set of policy tools intended to move decision-making from a process of incremental trial and error to one of experimentation that uses continuous monitoring, assessment, and recalibration. Ecosystem management and adaptive management are not interchangeable, but they are nearly inseparable (Nagle and Ruhl 2002). Successful ecosystem management usually requires some form of adaptive management, and use of adaptive management in the context of natural-resources conservation generally requires that goals be expressed in terms of ecosystem management.

Through research already completed, scientists and managers have come to understand much about Klamath basin ecosystems and the species that depend on them, but many of the important ecological and human processes and interactions that animate the ecosystem remain unknown. Furthermore, ecosystem processes, habitats, and species are modified continually by changing environmental conditions and human activities. Presently and in the future, uncertainty is inevitable. Adaptive management provides an iterative process for continually reducing uncertainty by refining the implementation of environmental restoration projects in response to information from monitoring and scientific analysis.

Extreme events such as drought, flood, and unexpected human actions are anticipated by a properly designed adaptive-management program. Adaptive management incorporates processes for early detection and interpretation of the unexpected and for maximizing the learning opportunities associated with these events. Adaptive management is valuable in that it treats all responses, expected or not, as learning opportunities.

An example of an incidental experiment from the Klamath basin is the variation of water levels of Upper Klamath Lake over the last 15 yr. Drought and human management have caused the water level of the lake to fluctuate over a range of about 6 ft (Chapter 3). Changes in water levels now can be compared with changes in water quality (Chapter 3) or in sucker populations (Chapter 6). A number of other experiments, planned or inadvertent, have occurred in the basin, such as changes in seasonal and annual flows at Iron Gate Dam; they provide useful information about recovery, but in many cases monitoring programs have been inadequate to support analysis and interpretation that would lead to adaptation of management based on the new information.

Key Components of Adaptive Management

The key components of adaptive management are as follows:

- *Definition of the problem.* Examples are loss of critical habitat for species and the need for protection and restoration of habitat for species, such as those listed under the ESA.
- *Determination of goals and objectives for management of ecosystems.* Examples are restoration of habitat protection and recovery of endangered species and other fish and wildlife resources at minimum social or economic cost.
- *Determination of the ecosystem baseline.* The ecosystem baseline includes all relevant information, past and present, such as physical, chemical, and biological features and benchmark indicators of the abundance of critical species. The baseline is the reference condition against which progress toward management goals is measured.
- *Development of conceptual models.* The analytical basis of adaptive management typically is a set of conceptual and numerical models. For example, conceptual ecological models convert broad, policy-level objectives into specific, measurable indicators of the status of natural and human systems. Conceptual modeling requires knowledge of ecosystem functions, of alteration or degradation, and of potential improvements. This information is framed in terms of major stressors and indicators (ecological attributes) that provide the most useful measures of ecological and social response to change. The conceptual model can be used to identify a small number of representative biological, chemical, and physical indicators of system-wide responses to restoration on various spatial and temporal scales. The indicators then can be used in developing models or protocols for monitoring and testing the efficiency of the restoration efforts. Performance measures are developed for each of the elements (ideally for both stressors and indicators) and are used as the standards for evaluating the restoration program.
- *Selection of future restoration actions.* The conceptual models shape the character of restoration actions by identifying key kinds of uncertainty or by revealing the extent of

confidence that a particular action will achieve a given objective. On the basis of past and curren conditions of the ecosystem, and insights from the conceptual models about the ecological and social consequences of management actions, managers apply two processes for changing management activities: identification of alternative-management procedures to achieve objectives and selection of alternatives that appear to move the system toward management objectives. One aspect of the selection process should be the social and economic costs of achieving an objective. When two alternatives are effective, lower cost is preferred. If alternative actions are proposed for the same purpose, comparison (perhaps in consecutive years) leads to selection of the action that most efficiently achieves the objectives.

- *Implementation of management actions.* A group of scientists and agency managers collectively is responsible for determining the criteria and procedures for management actions. This work requires coordination, organization, and accountability among the agencies, which can be difficult if the agencies have conflicting missions, as is the case in the Klamath basin. Experts in modeling, simulation, experimental design, and prediction forecast responses to managerial actions. Each iteration of simulation is tested through post-audit comparisons of observed and expected results. As part of an evaluation program, agency managers may support short-term and long-term experiments, such as alternative water levels or stream flows, habitat restoration efforts in selected areas, or other ecosystem changes. Experiments often involve major change, as would be the case for closure of the Iron Gate or Trinity Hatchery or removal of major dams (Chapter 8).
- *Monitoring of the ecosystem response.* "It is critical to monitor the implementation of restoration actions to gage how the ecosystem responds to management interventions. Monitoring provides the information necessary for tracking ecosystem health, for evaluating progress toward restoration goals and objectives, and for evaluating and updating problems, goals and objectives, conceptual models, and restoration actions. Monitoring requires measuring the baseline condition, abundance, distribution, change or status of ecological indicators" (CALFED Bay-Delta Program 2000).
- *Evaluation of restoration efforts and proposals for remedial actions.* After implementation of specific restoration activities and procedures, the status of the ecosystem is regularly and systematically reassessed and described. Comparison of the new state with the baseline state is a measure of progress toward objectives. The evaluation process feeds directly into adaptive management by informing the implementation team and leading to testing of management hypotheses, new simulations, and proposals for adjustments in management experiments or development of wholly new experiments or management strategies.

Status of Adaptive Management in the Klamath Basin

There has been little effort to implement adaptive-management strategies in the Klamath basin, except through the Trinity River Restoration Program, which deals only with the Trinity River. Even the 2002 biological assessment of the U.S. Bureau of Reclamation (USBR), which prescribes Klamath Project operations for the next 10 yr, gives only weak indications of mechanisms for adapting to new information. One exception is the proposed water bank, which if properly structured will provide annual information on the quantities of water available for voluntary transfer across uses and locations, and on the economic and social value of such water. This information can then be used by USBR to manage the water bank and to develop more accurate estimates of water availability for both agricultural and environmental uses in the basin, and to establish a long-term mechanism to address demands for water.

Ecosystem management in the Klamath basin typically has pursued the widely recognized alternatives to adaptive management: deferred action and trial and error involving crisis management In the deferred-action approach, management methods are not changed until ecosystems are fully understood (Walters and Hillborn 1978, Walters and Holling 1990, Wilhere 2002). This approach is cautious but has two notable drawbacks: deferral of management changes may magnify losses, and knowledge acquired by deferred action may reveal little about the response of ecosystems to changes in management. Stakeholder groups or agencies that are opposed to changes in management often are strong proponents of deferred action.

Crisis management is common throughout the Klamath basin and permeates most restoration efforts, particularly on the tributaries. The approach often involves restoration actions, but neglects assessment (Wilhere 2002). Thus, management becomes based principally on casual observations and anecdotal reports. Trial and error without assessment and adaptation undervalues information, which is the most critical need in restoration, and overvalues action for its own sake. The trial and error without assessment and adaptation may cause more harm than good, but its benefits typically cannot be determined.

The legislative potential for watershed planning and restoration based on an adaptive-management framework already exists through the Klamath Act (Public Law 99-552), which was passed by Congress in 1986. The act led to formation of the Klamath River Basin Conservation Area Restoration Program, which includes the Klamath Basin Restoration Task Force. The task force is comprised of federal, state, and local officials and representatives of several tribes and other stakeholders, including the private sector. In addition, other committees, organizations and ad hoc working groups, such as the Upper Klamath Basin Working Group, the Klamath Basin Ecosystem Foundation, and several watershed councils have been created for improvement of dialogue among parties in the basin, and for development of solutions to water issues within the basin. The task force and other groups have facilitated discussion, but it is not clear that any group has contemplated extensive use of adaptive management. Considerable public and private funds have been invested in restoration and management of the ecosystems of the Klamath basin. It is not clear what benefits have been derived from the investments, or how management will be improved as a result. Adaptive management as applied to the Klamath basin would need to function within the legal framework of the ESA (Chapter 9), but the key point of the process is to set goals, develop a plan, determine whether it is achieving specific goals, and make adjustments as needed to be effective. This approach is both ecologically and socially responsible, given that ultimately all agencies and other stakeholders have limited resources with which to operate. As specific goals are achieved, resources become available for other socially desirable purposes within and outside the basin.

POLICY OPTIONS AND RESTORATION ACTIVITIES

Federal legislation and regulations, including the ESA and Federal Tribal Trust responsibilities, supercede state laws, including state water law. Thus, water demands for ESA purposes or to meet treaty obligations to Indian tribes have generally been upheld by federal courts (see, for example, the Winters Doctrine). Since such federal rulings reinforcing the ESA or tribal water needs typically do not apply to all waters in a basin or watershed, the Prior Appropriation Doctrine is still the major allocation device for waters in much of the West, including the Klamath basin. The prior appropriation system requires that the first individual to divert water for a beneficial use shall have the right to do so into perpetuity ("first in time, first in right"). The right of use generally is defined in terms of a given amount of water at a particular point of diversion. The rights of later diverters are junior (subordinate) to the right of the first diverter (senior right); in times of shortage, those holding water rights with earlier diversion dates are the last to be denied water. These water rights are established and protected by the states in which the diversions occur, usually by a state department of water resources.

The prior appropriation system of rights provides an efficient mechanism for allocating water during times of shortage, but has many limitations (Getches 2003). One is that the use of water by the holders of senior rights (seniors) may in some cases be of lower economic or social value than that of holders of junior rights (juniors). For example, a senior may divert water onto pastureland, of low economic value while a junior has the opportunity to use water to produce crops of high value. In a time of drought, there may not be sufficient water for both users, and only the crop of lower value would receive water. A related issue is that the most senior water rights are for diversions, primarily to agriculture. Values of flow in the stream itself have only recently been recognized as beneficial. As a result, seniors have the potential to divert all usable flow, thus dewatering portions of streams, even if the marginal value of water in the stream could produce substantially higher benefits than the diversion.

Another shortcoming of the prior-appropriation doctrine as applied by most states is that water rights are defined for a specific location. Thus, water rights are tied to a particular parcel of land unless a change is approved by a state authority. Defining water rights as appurtenant to land creates inflexibilities in the use of the water (for example, it restricts water trading), which leads to substantial economic and social costs with respect to maximizing the value of water to society, as demonstrated in the example of the preceding paragraph.

Because of problems with the prior-appropriation doctrine, states began using water markets about 30 yr ago (Colby Saliba and Bush 1987, National Research Council 1992, Getches 2003). The idea of a water market is that willing buyers and sellers should engage in transfers of water, thereby increasing the value of water to society. To use the preceding example, the junior may be willing to pay more for water than the senior can realize from using it. In such a case, both parties would gain and society would have realized greater value through the transfer.

To facilitate creation of a water market, states have changed laws and rules to allow a water right to be separated from the land to which it was originally applied. In such cases, the right is redefined as a particular flow or volume of water instead of a diversion at a particular location. Thus, a downstream user can purchase water from an upstream user. The magnitude of the gain from such a transaction is determined by the seller's increase in returns (over the value of the water on site) plus the additional increase in income or averted loss realized by the downstream purchaser. Obviously, trades will not occur unless they are of mutual benefit to buyer and seller. The existence of a market also allows other prospective water users to obtain water that was previously unavailable. For example, conservation groups or fisheries agencies may purchase water for maintenance of stream flows that benefit fish and wildlife (Colby 1990, Adams et al. 1993). In some western states (such as, Colorado and Arizona) municipalities purchase agricultural water rights through water markets to meet rising water demand due to residential growth.

Water markets create their own problems. They include so-called third-party effects by which someone who is not party to the sale may be harmed. For example, harm could come to an irrigator who has been using return flows from an upstream irrigator. If the upstream irrigator ceases irrigation, there would be no return flows for the neighboring irrigator. In addition, some return flows create wetlands or supplement groundwater supplies; if the water is moved to a new location as a result of a water transfer, these local benefits may be lost.

Water markets also may affect rural communities. If large amounts of water are diverted from agriculture to other uses, rural communities, including Indian tribal groups, who depend on the economic activity generated by irrigated agriculture will suffer. Thus, although the traders gain from the existence of markets and society gains from water transfers to use of higher value, rural communities may lose economic viability.

Despite the problems created by water markets, their use is increasing throughout the West. Many of the western states allow water to be sold or leased. Permanent transfer of water rights occurs in the case of a true water market, but a water bank typically involves the temporary transfer (lease) of a water right. Water banks are particularly useful during drought. Water banks also reduce some of the adverse effects of a permanent transfer of a water right. Farmers and rural communities often are more supportive of the water-bank concept than of sales of water rights (Keenan et al. 1999).

Water banks hold promise for water problems such as those of the Klamath basin. As noted earlier, Indian tribal claims to waters of the upper Klamath basin must be addressed as part of the adjudication process. Remaining water rights then will be assigned based on demonstrated proof of the initiation of beneficial use. Indeed, the recent USBR biological assessment (2002) contains a 10-yr plan that calls for creation of a water bank of 100,000 acre-ft of water per yr (see Table 1-1 for comparison with total annual flows). The water would come from ground water and from surface water within and outside the Klamath Project. USBR would purchase the water, which would be used for environmental purposes.

The Klamath basin shows one of the necessary conditions for a water market or bank to be successful: a pronounced difference in the value of water across crops and other uses. For example, crops of both low and high value are grown in the Klamath Project and in the basin. In addition to providing a mechanism by which USBR could purchase water for environmental uses, a properly structured water bank would allow irrigators to trade among themselves. In a hypothetical analysis of the events of the 2001 water year in the Klamath basin, Jaeger (2002) has shown that a fully functioning water bank would have reduced losses to agriculture by over 50%. A water bank also could allow irrigation water to be shifted to nonagricultural uses. For example, the California water bank, which is administered by the California Department of Water Resources, reserves a small portion of each exchange between farmers to be used for environmental purposes in the Sacramento-San Joaquin delta.

The necessary economic conditions exist for a water bank in the Klamath basin, but institutional conditions do not. Specifically, before water can be traded, water rights must be clearly defined. In California, such rights have been established by the state. Oregon, however, has not finished the adjudication process for water rights in its portion of the Klamath basin. In the short term, water banking will need to rely on water sales from the California portion of the basin or among farmers in the Klamath Project who have water available for transfer, such as from wells. Even a limited water bank that is based on adjudicated surface water in California or from ground water in the Klamath Project has the potential to improve water allocation in the basin.

IMPROVEMENT OF RESOURCE MANAGEMENT IN THE KLAMATH BASIN

The present management structure for restoring the two sucker species and coho salmon in the Klamath basin consists of the federal agencies involved in the ESA Section 7 (a)(2) consultations—USBR, the U.S. Fish and Wildlife Service (USFWS), and the National Marine Fisheries Service (NMFS)—and, less directly, a number of other federal and state agencies, such as the U.S. Forest Service, Bureau of Land Management, U.S. Fish and Wildlife Service National Wildlife Refuges, the Natural Resource Conservation Service, the Bureau of Indian Affairs, the Environmental Protection Agency, the Army Corps of Engineers, the California and Oregon Departments of Environmental Quality, and state water-resources departments. Because the ESA is federal legislation, USBR, USFWS, and NMFS are the primary agencies that respond to ESA rules and procedures for the Klamath Project. Given the conflicting objectives and missions of these agencies, however, tensions among them are inevitable. ESA processes also have been joined by a number of advocacy groups that oppose or support actions of the various federal agencies. For example, the National Research Council staff has identified at least 29 environmental advocacy groups that have joined in litigation or taken positions against USBR and at least seven water-user advocacy groups that have brought suit against or opposed actions of USFWS. In addition, stakeholders in and outside the Klamath Project and local communities have not been adequately included in actions implemented under the ESA (Chapter 9). Entities outside the federal agencies feel disempowered by the present process (Lach et al. 2002). Their sense of powerlessness may contribute to the litigious nature of interaction among parties in the Klamath basin.

The current management structure includes the Klamath Basin Ecosystem Restoration Office (ERO), which fills two important functions in implementing the ESA in the Klamath basin: it provides money for research on the status of suckers in the upper basin, and it reviews USBR's biological assessments and prepares the USFWS biological opinions for the Section 7(a)(2) consultations. In fulfilling these functions, it operates essentially as a regulatory agency and could be viewed as an adversary to regulated parties (in this case, USBR and the irrigators in the Klamath Project). It also funds "restoration activities and practices" as part of the recovery program for the listed species. The activities and practices may lead to changes in land-use patterns on private lands in support of the sucker-recovery efforts.

The ERO serves as both a regulator and a funding agency; it is staffed primarily by USFWS personnel. It apparently does not effectively monitor and evaluate the success of its restoration actions. As noted earlier in this chapter, monitoring and evaluation are the most critical components of adaptive management for measuring the success of any ecosystem-restoration effort and incorporating new knowledge into the management process. In fact, USFWS and the ERO do not appear to have an operational recovery plan for the two sucker species (Chapter 9).

The underlying presumption of ERO managers appears to be that expenditure of money by the ERO on selected restoration actions is an acceptable measure of performance. In this regard, the ERO functions in a manner similar to that of many federal and state agencies in the basin that mistake input for output when evaluating their performance.

Federal and state emergency funding to assist farmers and agencies in 2001 was well intended but only exacerbated the problem of accountability. Similarly, the recent farm bill legislation that earmarked $50 million specifically for the Environmental Quality Incentives Program (NRCS 2003) and similar U.S. Department of Agriculture programs in the basin raises the issue of accountability in the absence of any central plan for recovery of the suckers. It is clear that the present level of emergency and supplemental funding for the basin may not be sustainable. Managers, therefore, need to have mechanisms in place to ensure that such funds, when available, are achieving the goals of the ESA recovery plans or, where appropriate, are being spent effectively in assisting stakeholders as they adjust to the consequences of the ESA.

Management of species in the Klamath basin should have two goals: maintenance and recovery of listed species and, among the actions that meet this objective, minimization of cost to society. The first goal is mandated by the ESA; the second is not the main objective of the ESA but is consistent with it (Chapter 9). The present management system in the Klamath basin is not ideal for reaching either goal.

If institutional deficiencies in the Klamath basin could be remedied, the likelihood of achieving the recovery of species and minimizing costs would increase. The design of research should begin with a broad set of objectives and scientific hypotheses; such breadth may require information from sources beyond local agencies and their supporting scientists and staff. The strong focus on water levels in Upper Klamath Lake and flows in the main stem, although driven by a desire to deal with issues over which the federal agencies have immediate control (through USBR operations), is indicative of an excessively narrow consideration of possibilities for restoration at the expense of other activities and solutions that may be effective over the long term. Furthermore, locations of restoration activities and their effects on water quality and habitat should be considered in the acquisition of land or other major investments. The assignment of priorities should recognize budgetary limitations of the agencies and others. Estimation of the cost effectiveness of restoration efforts is needed, as are the integrated monitoring and assessment programs to evaluate them.

Management requires external oversight by a committee or group capable of resolving conflicts between federal agencies. There appears to have been closer collaboration between USBR, USFWS, and NMFS in developing their most recent biological assessment and biological opinions than in previous years (Chapter 1), perhaps in response to external review. There is no guarantee, however, that such collaboration will continue and some mechanism should be in place for coordination of federal management efforts. For example, such a management role could be played by the Committee on Environment and Natural Resources of the National Science and Technology Council; this committee of the executive branch was founded for such purposes. At the same time that there is need for oversight of federal agencies, the management structure for ecosystem restoration needs to involve local groups and private landowners as well in the design of restoration activities and investments. As a part of these efforts, federal management agencies should recognize the nature of incentives in the ESA for private landowners to participate in ecosystem recovery. Specifically, the ESA may prohibit taking of endangered species by private landowners; it does not contain provisions that encourage landowners to increase the abundance of fish populations. Indeed, landowners who increase populations of endangered species on their land may face increased government regulation. Thus, although the ESA does not prohibit the use of incentives that would encourage landowners to promote the welfare of endangered species, it is often viewed by landowners as more stick than carrot. This perception could be changed by cooperative arrangements that promote the welfare of the listed species without threatening landowners.

Third, the management structure should, through monitoring and evaluation, improve the efficiency of expenditures for both research and restoration activities. That requires better mechanisms for setting spending priorities. Research demonstrates that cumulative effects are typical of stream restoration and that thresholds for recovery require implementation of corrective measures on a geographically broad scale (Adams et al. 1993, Li et al. 1994, Wu et al. 2000). The present pattern of federal, state, and private land acquisition for restoration in the upper Klamath basin shows little evidence of being guided by any systematic plan.

The process-oriented issues described above can be addressed by use of the adaptive-management framework, subject to the limitations imposed by the ESA. The Klamath River Basin Restoration Task Force (KRBRTF) or some other broadly constituted group may be a logical starting point in developing and implementing a set of basinwide restoration activities. At a minimum, an adaptive management approach, whether through an existing group or through a new entity, would address current shortcomings that arise from a lack of clearly defined benchmarks and a failure to monitor the biological and economic efficiency of current expenditures. The use of external advisory groups or panels for oversight would also provide fresh perspective and perhaps reduce some of the tensions and distrust inherent in the current system.

CONCLUSIONS

The listing agencies for endangered and threatened species in the Klamath basin accept adaptive management as a principle for pursuing restoration of these species, as does USBR. Even so, working examples of adaptive management in the upper Klamath basin are virtually absent. Erratic funding, lack of recovery plans, absence of systematic external review of research, and other deficiencies having to do with lack of continuity have been the direct cause of deficiencies in adaptive management.

Adaptive management is an ideal approach for the Klamath basin insofar as the effects of specific actions intended to benefit the endangered and threatened species cannot be evaluated fully except on a conditional trial basis. Conditional trials require thoughtful design and organized monitoring that will reveal responses to management actions. Efforts to implement ESA requirements for the benefit of fishes in the Klamath basin cannot succeed without aggressive pursuit of adaptive management principles, which in turn require continuity, master planning, flexibility, and conscientious evaluation of the outcomes of management.

11

Recommendations

BASINWIDE ISSUES

Scope of ESA Actions

Recovery of endangered suckers and threatened coho salmon in the Klamath basin cannot be achieved by actions that are exclusively or primarily focused on operation of USBR's Klamath Project. While continuing consultation between the listing agencies and USBR is important, distribution of the listed species well beyond the boundaries of the Klamath Project and the impairment of these species through land- and water-management practices that are not under control of USBR require that the agencies use their authority under the ESA much more broadly than they have in the past.

Recommendation 1. The scope of ESA actions by NMFS and USFWS should be expanded in several ways, as follows (Chapters 6, 8, 9).

- NMFS and USFWS should inventory all governmental, tribal, and private actions that are causing unauthorized take of endangered suckers and threatened coho salmon in the Klamath basin and seek either to authorize this take with appropriate mitigative measures or to eliminate it.
- NMFS and USFWS should consult not only with USBR, but also with other federal agencies (e.g., U.S. Forest Service) under Section 7(a)(1); the federal agencies collectively should show a will to fulfill the interagency agreements that were made in 1994.
- NMFS and USFWS should use their full authority to control the actions of federal agencies that impair habitat on federally managed lands, not only within but also beyond the Klamath Project.
- Within 2 yr, NMFS should prepare and promulgate a recovery plan for coho salmon, and USFWS should revise the recovery plan for shortnose and Lost River suckers. The new recovery plans should facilitate consultations under ESA Sections 7(a)(1), 7(a)(2), and 10(a)(1) across the entire geographic ranges of the listed species.

- NMFS and USFWS should more aggressively pursue opportunities for non-regulatory stimulation of recovery actions through the creation of demonstration projects, technical guidance, and extension activities that are intended to encourage and maximize the effectiveness of non-governmental recovery efforts.

Planning and External Review

For all three of the listed fish species, monitoring, research, and remediation have been handicapped by lack of effective central planning, by insufficient external review, and by poor connections between research and remediation (Chapters 6, 8, 10).

Recommendation 2. Planning and organization of research and monitoring for listed species should be implemented as follows.

- Research and monitoring programs for endangered suckers should be guided by a master plan for collection of information in direct support of the recovery plan; the same should be true of coho salmon.
- A recovery team for suckers and a second recovery team for coho salmon should administer research and monitoring on the listed species. The recovery team should use an adaptive management framework that serves as a direct link between research and remediation by testing the effectiveness and feasibility of specific remediation strategies.
- Research and monitoring should be reviewed comprehensively by an external panel of experts every 3 yr.
- Scientists participating in research should be required to publish key findings in peer-reviewed journals or in synthesis volumes subjected to external review; administrators should allow researchers sufficient time to do this important aspect of their work.
- Separately or jointly for the upper and lower basins, a broadly based, diverse committee of cooperators should be established for the purpose of pursuing ecosystem-based environmental improvements throughout the basin for the benefit of all fish species as a means of preventing future listings while also preserving economically beneficial uses of water that are compatible with high environmental quality. Where possible, existing federal and state legislation should be used as a framework for organization of this effort.

ENDANGERED LOST RIVER AND SHORTNOSE SUCKERS

Needs for New Information

The endangered suckers have been extensively studied, particularly in Upper Klamath Lake, in ways that have proven very useful to the diagnosis of causes for decline in the abundance of suckers. Research and monitoring programs will continue to be valuable in revealing mechanisms that cause decline of the listed species, in developing a scientific basis for recovery actions, and in evaluating trial remediation measures through adaptive management.

Research that is focused on gaps in knowledge or on mechanisms that appear to be particularly important to the recovery of the suckers will be most useful in support of the recovery effort.

Recommendation 3. Research and monitoring on the endangered suckers should be continued. Topics for research should be adjusted annually to reflect recent findings and to address questions for which lack of knowledge is a handicap to the development or implementation of the recovery plan. Gaps in knowledge that require research in the near future are as follows (Chapters 5, 6).

- Efforts should be expanded to estimate annually the abundance or relative abundance of all life stages of the two endangered sucker species in Upper Klamath Lake.
- At intervals of 3 yr, biotic as well as physical and chemical surveys should be conducted throughout the geographic range of the endangered suckers. Suckers should be sampled for indications of age distribution, qualitative measures of abundance, and condition factors. Sampling should include fish other than suckers on grounds that the presence of other fish is an indicator of the spread of nonnative species, of changing environmental conditions, or of changes in abundance of other endemic species that may be approaching the status at which listing is needed. Habitat conditions and water-quality information potentially relevant to the welfare of the suckers should be recorded in a manner that allows comparison across years. The resulting survey information, along with the more detailed information available from annual monitoring of populations in Upper Klamath Lake, should be synthesized as an overview of status.
- Detailed comparisons of the Upper Klamath Lake populations (which are suppressed) and the Clear Lake and Gerber Reservoir populations (which are apparently stable), in combination with studies of the environmental factors that may affect welfare of the fish, should be conducted as a means of diagnosing specific life-history bottlenecks that are affecting the Upper Klamath Lake populations.
- Multifactorial studies under conditions as realistic as practicable should be made of tolerance and stress for the listed suckers relevant to poor water-quality conditions in Upper Klamath Lake and elsewhere.
- Factors affecting spawning success and larval survival in the Williamson River system should be studied more intensively in support of recovery efforts that are focused on improvements in physical habitat protection for spawners and larvae in rivers.
- An analysis should be conducted of the hydraulic transport of larvae in Upper Klamath Lake.
- Relevant to the water quality of Upper Klamath Lake, more intensive studies should be made of water-column stability and mixing, especially in relation to physiological status of *Aphanizomenon* and the occurrence of mass mortality; of mechanisms for internal loading of phosphorus; of winter oxygen concentrations; and of the effects of limnohumic acids on *Aphanizomenon*.
- A demographic model of the populations in Upper Klamath Lake should be prepared and used in integrating information on factors that affect individual life-history stages.
- Studies should be done on the degree and importance of predation on young fish by nonnative species.
- Additional studies should be done on the genetic identities of subpopulations.

Remedial Actions

Because the suckers currently are not showing evidence of recovery, new types of actions intended to promote recovery are essential. The main focus of action in the recent past has been maintenance of specific minimum water levels in Upper Klamath Lake. Current evidence suggests that these manipulations will not be effective in causing restoration of suckers in Upper Klamath Lake, despite evidence that higher water levels maximize certain habitat features that are known to be important to the suckers. Additional harm to the suckers might result, however, from changes in the Klamath Project operations that would allow greater degrees of mean or maximum drawdown than those observed in the 1990s. USFWS may continue to investigate the effects of lake level in a more directed way by collaborating with USBR in experiments involving water-level manipulations. Some new types of manipulations not produced by past operating procedures might be especially informative. In planning experiments USFWS should consider the possibility that sustained high water levels could be detrimental to the suckers by increasing the severity of mass mortality through maintenance of high water-column stability, thus exacerbating surface oxygen depletion at times of mixing during the late growing season. Water levels in Clear Lake and Gerber Reservoir appear to have been adequate to sustain stable populations except at extreme drawdown, the occurrence of which is a risk to the suckers.

Current evidence indicates that attempts to intercept nutrients from the watershed will not improve the quality of water of Upper Klamath Lake, and thus cannot be taken as a likely way to achieve recovery of suckers.

Recovery actions for suckers of Upper Klamath Lake at present should emphasize measures that maximize production and survival of young fish on the basis that additional recruitment into the subadult and adult stages could partially or fully offset mass mortality of adults. In addition, experiments should be done on artificial oxygenated refugia that may be used by large fish. Recovery planning should assume that, because mass mortality of adults will likely continue in Upper Klamath Lake, significant efforts should be made to establish self-sustaining populations elsewhere in the Klamath basin.

Recommendation 4. Recovery actions of highest priority based on current knowledge of endangered suckers are as follows (Chapter 6):

- Removal of Chiloquin Dam to increase the extent of spawning habitat in the upper Sprague River and expand the range of and conditions under which larvae enter Upper Klamath Lake.
- Removal or facilitation of passage at all small blockages, dams, diversions, and tributaries where suckers are or could be present.
- Screening of water intakes at Link River Dam.
- Modification of screening and intake procedures at the A Canal as recommended by USFWS (2002).
- Protection of known spawning areas within Upper Klamath Lake from disturbance (including hydrologic manipulation, in the case of springs), except for restoration activities.
- For river spawning suckers of Upper Klamath Lake, protection and restoration of riparian conditions, channel geomorphology, and sediment transport; elimination of disturbance at

locations where suckers do spawn or could spawn. These actions will require changes in grazing and agricultural practices, land management, riparian corridors, and public education.

- Seeding of abandoned spawning areas in Upper Klamath Lake with new spawners and physical improvement of selected spawning areas.
- Restoration of wetland vegetation in the Williamson River estuary and northern portions of Upper Klamath Lake.
- Use of oxygenation on a trial basis to provide refugia for large suckers in Upper Klamath Lake.
- Rigorous protection of tributary spawning areas on Clear Lake and Gerber Reservoir, where populations are apparently stable.
- Reintroduction of endangered suckers to Lake of the Woods after elimination of its nonnative fish populations.
- Reestablishment of spawning and recruitment capability for endangered suckers in Tule Lake and Lower Klamath Lake, even if the attempts require alterations in water management, provided that preliminary studies indicate feasibility; increased control of sedimentation in Tule Lake.
- All proposed changes in Klamath Project operations should be reviewed for potential adverse effects on suckers; water level limits for the near future should be maintained as proposed by USBR in 2002 but with modifications as required by USFWS in its most recent biological opinion (2002).

COHO SALMON

Needs for New Information

While the biology of coho salmon is well known in general, studies of coho salmon specific to the Klamath River basin have been few and do not provide the requisite amount of information to support quantitative assessments of population strength and distribution, environmental correlates of successful spawning and rearing, overwintering losses and associated habitat deficiencies, water temperatures at critical points in tributary waters, and effects of hatchery-reared fish on wild coho. Mainstem conditions are primarily of interest with respect to the spawning run and the downstream migration of smolts. Tributary conditions, which have been much less studied than mainstem conditions, are critical to both spawning and rearing; habitat includes but extends beyond the main stems of the large tributaries and into the small tributaries and headwaters that strongly favor spawning and rearing of coho.

Recommendation 5. Needs for new information on coho salmon are as follows (Chapters 7, 8).

- Annual monitoring of adults and juveniles should be conducted at the mouths of major tributaries and the main stem as a means of establishing a record of year-class strength for coho. Every 3 yr, synoptic studies of the presence and status of coho should be made of coho in the Klamath basin. Physical and chemical conditions should be documented in a manner that allows interannual comparisons. Not only coho but other fish species present in coho habitats should be sampled simultaneously on grounds that changes in the relative abundance of species are relevant to the welfare of coho and may serve as an early warning of declines in the abundance of other species. Results of synoptic studies, along with the annual monitoring at tributary mouths, should be synthesized as an overview of population status at 3-yr intervals.

- Detailed comparisons should be made of the success of coho in specific small tributaries that are chosen so as to represent gradients in potential stressors. The objective of the study should be to identify thresholds for specific stressors or combinations of stressors and thus to establish more specifically the tolerance thresholds for coho salmon in the Klamath basin.
- The effect on wild coho of fish released in quantity from hatcheries should be determined by manipulation of hatchery operations according to adaptive-management principles. As an initial step, release of hatching fish from Iron Gate Hatchery (all species) should be eliminated for 3 yr, and indicators of coho response should be devised. Complementary manipulations at the Trinity River Hatchery would be desirable as well.
- Selected small tributaries that have been impaired should be experimentally restored, and the success of various restoration strategies should be determined.
- Success of specific livestock-management practices in improving channel conditions and promoting development of riparian vegetation should be evaluated systematically.
- Relationships between flow and temperature at the junctions of tributaries with the main stem and the estuary should be quantified; possible benefits of coordinating flow management in the Trinity and Klamath main stem should be studied.

Remediation

Actions intended to improve environmental conditions for the threatened coho salmon to date primarily have involved hydrologic manipulation of the main stem at Iron Gate Dam. Continual focus on hydrologic conditions in the main stem is an excessively narrow basis for recovery actions or for a recovery plan in that coho salmon are strongly oriented toward tributaries for all phases of the freshwater phase of their life cycle except migration at the adult and smolt stages. Changes required by NMFS in the flow of the main stem include additional water specifically for smolt migration; it is unknown whether this will be a major benefit to coho, but in the absence of information to the contrary it is a reasonable requirement. Establishment of more stringent minimum flows for the other parts of the year, as compared to the operations during the 1990s, are of uncertain benefit to coho salmon, although they may be of substantial benefit to other species that use the main stem more extensively. In apportioning responsibility to USBR for providing minimum flows according to its proportional use of water, NMFS is recognizing in a realistic way the need for all consumptive uses to be factored into any minimum-flow regime.

Major tributaries as well as small tributaries must benefit from remediation if recovery is to occur. Although more detailed information would be desirable as a basis for remediation, beginning points for remediation are obvious in locations where tributaries have been critically dewatered or warmed to the lethal threshold for coho salmon (a problem that could be exacerbated by climate change), or where appropriate substrate has been eliminated and cover is absent. Thus, there is ample justification for beginning remediation immediately. This will require extensive work on private lands, and also the establishment of improved management practices for mining and forestry, some of which is under the direct control of other agencies that are subject to ESA authority through NMFS. Blockage of coho migration, which occurs in dozens of locations at various scales within the Klamath basin, is inconsistent with ESA regulations on take and must be dealt with by NMFS.

Recommendation 6. Remediation measures that can be justified from current knowledge include the following (Chapter 8).

- Reestablishment of cool summer flows in the Shasta and Scott rivers in particular but also in small tributaries that reach the Klamath main stem or the Trinity main stem where water has been anthropogenically warmed. Reestablishment of cool flows should be pursued through purchase, trading, or leasing of groundwater flows (including springs) for direct delivery to streams; by extensive restoration of woody riparian vegetation capable of providing shade; and by increase of annual or seasonal low flows.
- Removal or provision for effective passage at all small dams and diversions throughout the distribution of the coho salmon, to be completed within 3 yr. In addition, serious evaluation should be made of the benefits to coho salmon from elimination of Dwinnell Dam and Iron Gate Dam on grounds that these structures block substantial amounts of coho habitat and, in the case of Dwinnell Dam, degrade downstream habitat as well.
- Prescription of land-use practices for timber management, road construction, and grazing that are sufficiently stringent to prevent physical degradation of tributary habitat for coho, especially in the Scott, Salmon, and Trinity river basins as well as small tributaries affected by erosion.
- Facilitation through cooperative efforts or, if necessary, use of ESA authority to reduce impairment of spawning gravels and other critical habitat features by livestock, fine sediments derived from agricultural practice, timber management, or other human activities.
- Changes in hatchery operations to the extent necessary, including possible closure of hatcheries, for the benefit of coho salmon as determined through research by way of adaptive management of the hatcheries.

COSTS

The costs of remediation actions are difficult to estimate without more detail on their mode of implementation by the agencies. Based on general knowledge of costs of research and monitoring at other locations, an approximate figure for the recommendations on endangered suckers over a 5-yr period is approximately $15-20 million, including research, monitoring, and remedial actions of minor scope. Excluded are administrative costs and the costs of remedial actions of major scope (e.g., removal of Chiloquin Dam), which would need to be evaluated individually for cost. For coho salmon, research, monitoring, and remedial projects of small scope over 5 yr is estimated at $10-15 million. Thus, the total for all three species over 5 yr is $25-35 million, excluding major projects such as removal of dams. These costs are high relative to past expenditures on research and remediation in the basin, but the costs of further deterioration of sucker and coho populations, along with crisis management and disruptions of human activities, may be far more costly. A hopeful vision is that increased knowledge, improved management, and cohesive community action will promote recovery of the fishes. This outcome, which would be of great benefit to the Klamath basin, could provide a model for the nation.